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# TRIUMPHS OF GENIUS

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Containing a detailed account of the discovery and practical application of certain ancient and modern inventions, together with the uses of Art in Literature, the Church and the Stage.

# TRIUMPHS OF GENIUS

BY
W. SANFORD RAMEY

ILLUSTRATED

A. R. KELLER CO.
PHILADELPHIA
1893

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# PREFACE.

THE title of this book but vaguely denotes its true character. Instruction as to the finely subtle significance of certain passages, which, but for such explanation, might seem to have no particular meaning at all, is, of course, the apparent purpose of the "few words by way of introduction."

Special regard to the "living interest" is a particular feature of the contents. Many of the incidents relative to the subject in this volume have been taken by the author verbally from those closely identified with such interests, and the author, during the time of collecting material for the work, has visited almost every city of prominence in the United States. Biographies or historical reminiscences, aside from statistical value, possess but little interest when culled either from the pages of the encyclopædia or books of historical libraries.

This volume is not intended as a book of reference, although dates for events are not lacking. The work is rather a novelty in the way of abridgment and conciseness, uniting in an unbroken story the historical, biographical, and statistical elements of each topic in the book. The author has especially avoided treading in well-worn paths, and has hewn through the forest of literature a new road that is at least interesting from its novel direction, if for no other reason.



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Much of the color and flavor of that great mind-fruit, the book, depends upon the atmosphere in which the ideas have ripened, the soil whence the sweet or sour juices have been drawn.

Many literary productions which we prize among the brightest of our national glories have grown out of human lives, rooted sometimes in sorrow, sometimes in joy. The indelible hues upon the pages which the author writes show the shifting of scenery amid which the inventor, the artist, the merchant, the mechanic, or the professional man plays out his fleeting existence in triumph or defeat.

It may be said that there are three stages of general opinions regarding the development and realization of a new and novel idea.

1. The skeptic will say that it is impossible.

2. He will say that it is not practical, therefore not valuable.

3. That it has long been known, and only needed application of certain principles which many might have accomplished by giving the matter close attention.

It is that consistency of physical and mental actions united at all times to battle against failure in its various guises which chronicles in this volume not the defeats, but the Triumphs of Genius.

PHILADELPHIA, May 29th, 1893.

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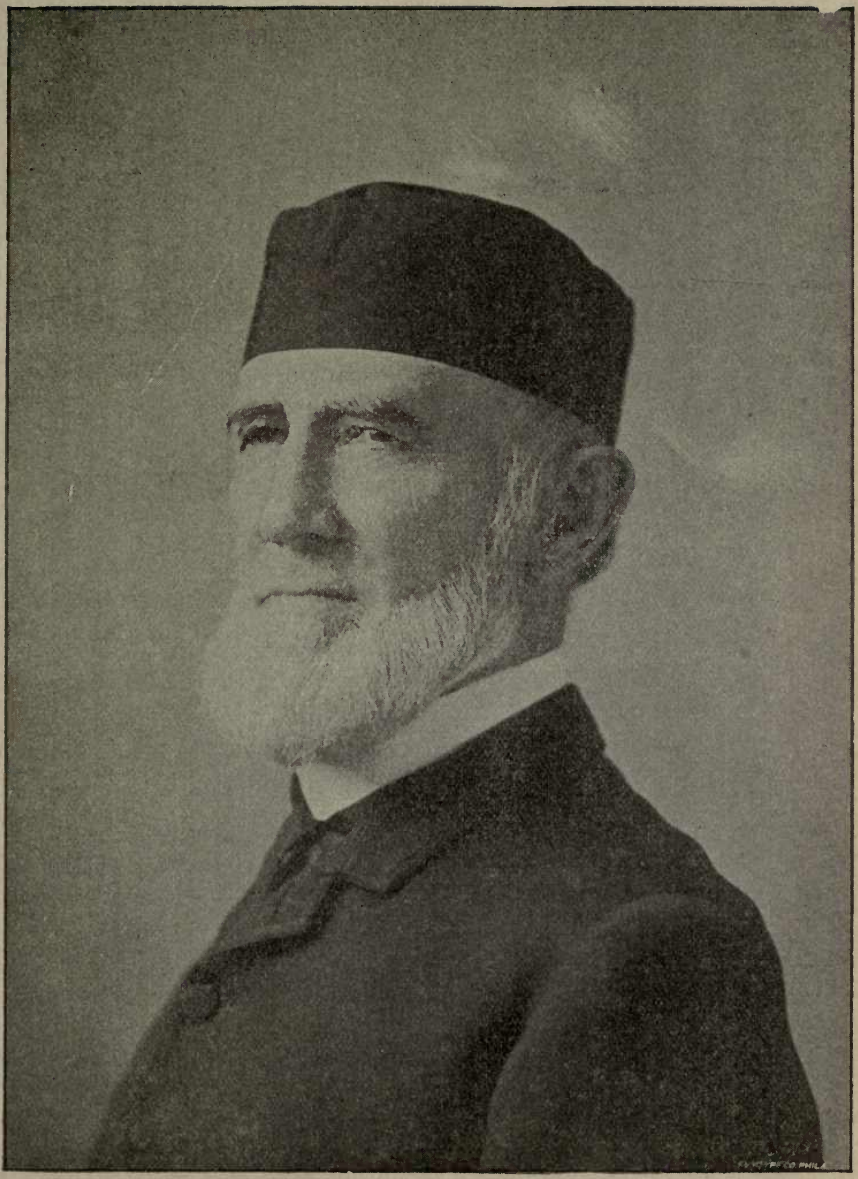


CAPT. JOHN B. EADS.

## THE EADS JETTIES.

WHEN Destiny foreordains a man to some great work she realizes that "efficiency depends upon concentration," and precluding the possibilities of his cultivating all the faculties of his mind, centres his energies upon the one faculty necessary to the fulfillment of his predestined achievements. She jealously guards him from the broadening curriculum of the schools and confines him with the iron manacles of poverty in a narrow channel, forcing his mind to draw its succulence from its own original conceptions. She locks him up within himself, and makes poverty the door-keeper, and this stern guardian soon teaches him the futility of repinings, and sets him groping about in the recesses of his own mind to find the key to unlock his prison-house.

Eads was no exception to this rule. Born in the village of Laurenceburg, Ind., May 23d, 1820, he had scarcely mastered the rudiments of an education when Destiny, recognizing the necessity of withdrawing him from the expanding influence of schools, swept his father's fortune from his hands, and, following him with determined steps, burnt the steamer on which he and his family had embarked to seek fairer fortunes in a distant West. Stranded in St. Louis at the age of thirteen, the young James found urgent necessity to assist in

providing sustenance for himself and parents. With that energy and decision which peculiarly distinguished him in after years, he seized the first thing that presented itself, and began peddling apples in a city afterward only too proud to do him homage and claim him as her citizen. Shortly afterward he succeeded in obtaining employment in a mercantile house; and Mr. Barrett Williams, the senior partner of the firm, discovering the taste of young Eads for mechanics, gave him free access to his library. Seizing with avidity this opportunity of studying the great principles of mechanics and civil engineering, Mr. Eads acquired during the several years of his employment by Mr. Williams a more thorough knowledge of these subjects than the average student brings with him from academic halls. Abandoning the counter, his mind imbued more with laws and principles of civil engineering than with price currents, Mr. Eads accepted a position as clerk on a Mississippi steamer, serving in this capacity two years. It was while he was thus borne to and fro on its restless current that he studied the vagaries and profound mysteries of the giant stream over whose broad bosom he was destined to fling a highway for the nations, and whose entrance to the sea he was to curb and trace with the unerring hand of genius.

In 1842, he formed a co-partnership with Case & Nelson, boat-builders, for the purpose of recovering steamboats and cargoes wrecked in the river. Mr. Eads had personal supervision of this branch of the business; and though the machinery and appliances were of the most primitive character and wholly inadequate to the work, he, by unprecedented fertility of resource and unflagging energy, was so successful that in a few years the wrecking operations of the firm ex-

tended the whole length of the Mississippi, and their property grew in ten years from little more than a nominal value to be worth nearly a half million.

In 1857, Mr. Eads, being in delicate health, retired from business, and as he then thought, to undisturbed and placid seclusion. This proved, however, to be but a temporary resting on his oars to gather strength for those brilliant feats in engineering that make him one of the greatest of American citizens. When the ominous and sullen roar of the civil war first broke the peaceful serenity of the Republic, Mr. Eads was called to Washington, and on August 7th, 1861, signed a contract by which he agreed to build seven gun-boats in sixty-five days, though the wood of which they were to be constructed was yet standing in the forests, and the rollers were not yet fashioned for shaping their iron armor. Sternly self-reliant, Mr. Eads drew his assurance of success from an inner source, an assurance that became an embodied reality within the prescribed sixty-five days. On the 12th of October, the gun-boat "De Kalb" was launched from the Carondelet wharf, in St. Louis, the other six following in quick succession. The splendor of this achievement was only the initiative to the glory won by the iron fleet constructed by Eads. By its aid was accomplished the brilliant capture of Forts Henry and Donelson, and the ever-memorable midnight passage of Island No. 10, which compelled the surrender of that redoubtable stronghold.

As a recognition of his abilities, the Missouri State University conferred on Mr. Eads the degree of LL. D. He was twice elected President of the St. Louis Academy of Sciences, and made other positions of honor and trust were tendered him.

As late as 1873 the Mississippi interposed its sullen waters between St. Louis and its principal railroad lines. Trains that came to discharge their wealth into the bosom of St. Louis were forced to rein in their iron steeds a mile away at the kiss of dark and treacherous waters, and by tedious transfer send forward their freight to its destination. Now the trains come swinging into the city eighty feet above the turbid stream on a track supported by a magnificent bridge, whose gigantic footsteps were planted on solid rock, a hundred feet below the water level, and whose graceful arches were spun from bank to pier and pier to bank by the energy and genius of James B. Eads. It is a monument of his determined purpose and engineering skill, and is a graceful exposition of new theories tested upon a scale of the greatest magnificence.

The conflict between two rival bridge companies being settled by their consolidation, Mr. Eads was made Engineer-in-Chief, and in August, 1867, he awarded the contract for masonry to James Andrews, of Allegheny, Pa. By the spring of 1868 all the details and drawings had been carefully compared and improved, and the whole structure was complete in the mind of the great engineer. The piers were to be carried through the sand and sediment of the river bed and rest on solid subterranean rock. Coffer dams were built, and caissons of iron prepared, on the roof of which the granite foundations of the pier were laid. As the caisson gradually sunk by the superincumbent weight, its course was shielded from deflection by steering ropes, while fresh masony was built above the level of the water. By a system of air locks workmen were let down under the water, and when the caisson with its superimposed pier reached the river bottom

the sand intervening between it and bed-rock was removed by force pumps ingeniously contrived by Captain Eads. The foundation of the east pier found its rocky resting place at a depth of one hundred and ten feet below the water level.

The two abutments and two piers were completed in 1872, and the contract for the superstructure, the plan of which was as bold and more original than the foundations, was awarded to the Keystone Bridge Company, of Pittsburgh, and that for approaches to the Baltimore Bridge Company. There are three magnificent arches, the terminal ones each with a span of five hundred and the central one of five hundred and twenty feet. Each arch has four ribs composed of two parallel systems of steel tubes twelve feet long and eighteen inches in external diameter, the whole held together by two enveloping half-cylinders coupled with steel pins. The tracery of this net-work of tubes is delicate and beautiful as a work of art, and yet so strong as to support a railway track, along which fifty trains daily come and go. In conjunction with the bridge is a tunnel burrowing under the heart of the city, into which the trains disappear after crossing the bridge, making their exit at the other end in Union Depot. The entire length of the bridge is two thousand two hundred and twenty-five feet, and the total cost of its construction ten millions of dollars. Throughout the seven years of its construction Captain Eads was Chief Engineer and principal stockholder, and he is responsible for every novelty in design and execution, and every detail bears the stamp of his genius. On the 4th of July, 1874, the great bridge was formally opened to the public by an imposing celebration, in which Captain Eads was the hero of the hour.

There had long been a recognized necessity for deepening

the channel at the mouth of the Mississippi. The great river, after being for fifteen hundred leagues the busy interchanger of commercial interests, drops into lazy old age as it nears the hour of its final extinction in the sea. Full of dash and spring in its early life in the far-off North, a Southern languor here pervades the sluggish stream. Diffusing its waters into three wide fans, it idly slips into the sea, and, as though determined that the industries of man should not crowd upon these last few indolent hours of its life, it placed a huge immovable bar where its sweet waters first mingle with the salt. One hundred years and more, men had been trying to make a channel for their vessels by scratching and scraping at this bar, but, with reckless indifference to their interests, the old river kept sifting his sands back into the furrows made by scraper and harrow. It needed some diviner prophet with diviner methods to instil into the sluggish stream some of the elixir of its youth and by some subtle means induce it again to take up its burdens. Eads responded to the call made by a hampered commerce and the crippled interests of the two great cities of St. Louis and New Orleans, and proposed by a novel method to compel the river itself to wash out a channel for the ingress and egress of the largest vessels. He laid his proposition before Congress February, 1874, the citizens of New Orleans filing a bill at the same time to open the river mouth by the St. Philip Canal. Captain Eads found a furious storm of opposition awaiting him among the United States Engineers, and sectional strife between New Orleans and St. Louis. The press of New Orleans accused Captain Eads with being in collusion with the great railway lines. By defeating the St. Philip Canal Bill he would continue the blockade at the mouth

of the river, he would further his own interests, which were centered in the great railway bridge at St. Louis, then approaching completion.

Though Captain Eads gave a most detailed and lucid explanation of the groundwork of his belief in the jetty system, the Jetty Bill received but eighty-nine votes in the House, while the Canal Bill received one hundred and eighteen. The Canal Bill was hurried into the Senate, but this body decided that a committee of seven engineers be appointed to investigate the comparative merits of a canal and the jetty system for opening the river mouth. This committee visited Europe, and in January, 1875, presented their report to Congress, in which they recommended the jetties, as the result of their investigations at the mouth of the Mississippi and the various river-mouths in Europe. Captain Eads had also been in Europe examining the principal jetties and consulting the engineers who constructed them, and immediately filed a new bill to make a channel thirty feet deep at the mouth of Southwest Pass, for eight million dollars. The bill passed both houses, but was amended so as to apply to South Pass, instead of Southwest Pass, in spite of all the arguments Captain Eads could use. With sublime magnanimity, the Senate informed Captain Eads if he would produce the same width and depth in the small Pass he had proposed to obtain in a Pass four times as large, and build the works for five million two hundred and fifty thousand dollars, which was ninety-two thousand one hundred and ten dollars less than was estimated by its own Commission, would be required, and guarantee its maintenance for twenty years for thirty thousand dollars less annually than the Commission's estimate for that item the improvement would be confided to

him. Moreover, the first payment of five hundred thousand dollars was not to be made till a depth of twenty feet and a width of two hundred feet was gained.

Captain Eads was tendered a complimentary banquet in St. Louis, in honor of his success in securing the passage of his bill, at which were present distinguished and representative men from all parts of the Mississippi valley. In reply to a toast, Mr. Eads spoke in eloquent and enthusiastic terms of the proposed jetties. "If the profession of an engineer were not based upon exact science," he concluded, "I might tremble for the result, in view of the immensity of the interests dependent on my success. But every atom that moves onward in the river is controlled by laws as fixed and certain as those which direct the majestic march of the heavenly spheres. I therefore undertake the work with a faith based upon the ever constant ordinances of God Himself; and so certain as He will spare my life and faculties, I will give to the Mississippi River, through His grace, and by the application of His laws, a deep, open, safe, and permanent outlet to the sea."

Captain Eads, accompanied by Mr. James Andrews, arrived at South Pass, May, 1875. He was presented with a complete map of the Pass, and on this chart he drew the lines of the proposed jetties. Mr. Andrews was given the contract to construct the works, his success in the St. Louis bridge and tunnel inspiring Captain Eads with all confidence in his ability. A large force of men were located along the low, marshy banks, and the unbroken silence of centuries was now startled by the noises of the axe and anvil, pile-driving and steam whistling.

The jetties are simply artificial banks constructed on

the bed of the river, and the water thus held in a narrow channel, gathers a new impetus, and washes out by its newly acquired force a deep and lasting channel.

Work was begun on the jetties June 17th, 1875, by driving piles. To these mattresses made of willows and sunk by stone were made securely fast. By an improved method, invented by Captain Eads and Mr. Andrews, a mattress one hundred feet long, thirty-five feet wide, and two feet thick could be made and launched in two hours, the old way requiring two days.

The works were approved by the Advisory Board of Engineers which met in New York September 2d and at Port Eads November 18th, 1875. At the end of the first year the jetties were simply walls of uncompressed willows, but important results had been effected. The channel had deepened rapidly from eight to sixteen feet across the bar. Friends and representatives of the press in St. Louis chartered the "Grand Republic" and made an excursion to the jetties, reaching Port Eads April 26th, 1876. While the resident engineer was preparing to welcome the magnificent steamer a government boat belonging to the department of Major Howell, United States Engineer, suddenly came in sight. Major Howell's assistant boarded the "Grand Republic" and made the apparently official and reliable statement that Captain Eads' alleged sixteen feet of channel depth did not exist; that a shoal was moving out diagonally in front of the jetties, and that the bar was moving seaward. Great distrust was produced in the minds of many on the "Republic," and this distrust spread rapidly as an infection among the friends and stockholders of the enterprise so that it was said stock was offered at half its face value. To restore confidence in him-

self and the jetties and stop the panic, if such existed in the money market, Captain Eads immediately wrote to Superintendent Patterson, of Coast Survey, requesting that Assistant Marindin, then at the jetties, be ordered to sound the channel, but this was denied on the ground that the duty belonged to General Comstock. Captain Brown, Assistant to General Comstock, made a survey of the jetties, but refused Mr. Eads the result, as he must first make his report to General Comstock. Captain Eads then telegraphed Secretary of War to instruct General Comstock to give him desired information, but no reply coming to the message, General Comstock left the jetties, declining to give the soundings till he had reported to General Humphreys, Chief Engineer U. S. A. Realizing the imperious necessity of having official certification of his own report and confutation of Major Howell's, Captain Eads telegraphed Superintendent of Coast Survey requesting that Marindin be permitted to give result of his soundings, but he was again baffled. He then requested Secretary of War to obtain from Superintendent of Coast Survey a comparative chart of soundings made May, 1875, before the construction of jetties, and May, 1876. The Superintendent of Coast Survey denied the right of Secretary of War to ask for the chart. Captain Eads then appealed to Secretary of Treasury to instruct Superintendent of Coast Survey to furnish the chart. This was refused on the ground that provision was made in the Jetty Act that all information should be furnished by War Department. Captain Eads finally appealed to House of Representatives, and through this body, after three months of harrowing delay, received the official confirmation of his statements and the complete refutation of Major Howell's. The refutation had come in a different way long before this,

however. On May 12th Captain Gayer had carried his iron steamship, "Hudson," drawing fourteen feet six inches, through the jetties when the tide was six inches down, still falling, and creating a strong seaward current. "Head her for the jetties!" was what he said when the pilot had reported condition of tide, and on she came like a thing of life, till, trembling with her triumph, she cast her anchor in deep water at Port Eads. Captain Gayer materially assisted the enterprise in one of its darkest hours. However, official jealousy and antagonism in withholding such important reports from Captain Eads cost him one hundred and eighty thousand dollars, the price of a dyke three thousand two hundred and fifty feet long which he had just completed and which he was now compelled to abandon. East Dyke will forever remain as a monument of official jealousy and antagonism.

October 5th, 1876, a careful survey of the channel showed a depth of twenty and a width of two hundred feet, and Mr. Eads was clearly entitled to his first payment, but official and legal wrangling deferred it till December 27th. This sum was immediately consumed in paying off indebtedness and meeting obligations. The spring and summer of 1877 found Captain Eads laboring under severe financial embarrassment. In August the pay-rolls were two months overdue and expensive work at head of Passes imperative. No more money from the government could be expected till the depth of twenty-two feet was gained. Messrs. Eads and Andrews had both gone North to raise money, but not meeting with success Captain Eads telegraphed Resident Engineer Corthell: "Discharge all the force unless they are willing to work for certificates payable on receipt of twenty-two feet payment." The situation was briefly explained to the men, and only two out

of the seventy-six abandoned the work. In January, 1878, Captain Eads received second payment of five hundred thousand dollars. Certain modifications were then made in the conditions imposed by the Jetty Act, and the finances of the work were placed on a sound basis for construction, when the sudden appearance of yellow fever suspended operations. The scourge invaded Port Eads, disbanded the working force, sent some to die in other places, and some it laid in lonely graves in sight of their almost completed work.

The jetties were finished July, 1879, Captain Eads having succeeded in obtaining the depth and width in the smaller Pass that he had proposed to create in one four times as large. The benefits that have accrued to the agricultural and commercial interests of the great valley, of which this is the outlet, may be inferred from a letter by General Bussey, President Chamber of Commerce, New Orleans: "Since completion of the jetties, there have been no complaints of detention at the bar. Vessels of the largest class, heavily loaded, pass through the jetties. The exports and imports have largely increased, and the high rates for freight have been lowered to a reasonable figure. We may safely estimate that the sum saved to producers in the Mississippi Valley will amount to five millions of dollars annually."

To the honor of Captain Eads, be it said that in no instance in the world has such a vast volume of water been placed under such absolute and permanent control through methods so economic and simple as those adopted at the head of the Passes of the Mississippi River. To Eads must forever belong the glory of having first unlocked the portals of the richest valley in the world, and thrown wide the gates for the commerce of the nations.

Immediately after the publication of the proceedings of the Inter-oceanic Canal Congress, held at Paris under the auspices of Count De Lesseps, in 1879, Captain Eads published a letter in the New York *Tribune*, containing a project for a ship railway across the Isthmus of Tehauntepec, Mexico, as a substitute for the sea-level canal proposed by that convention. He argued that the railway could be built in one quarter the time, and one quarter the cost of the canal; could transport ships at greater rapidity, with absolute safety, and the expense of maintaining and operating it would be less than that of the canal. Mr. Eads urged the matter so strenuously afterward, and his engineering skill being vindicated by such monumental achievements as the St. Louis bridge and the jetties, that he secured the most liberal concessions from the Mexican government. He then submitted the matter to the Congress of the United States in 1882. Though his bill was favorably reported to the Senate by the Committee on Commerce, this body failed to act on it. The bill did not request money to construct the railway, but simply desired that the government should guarantee the payment for a period of fifteen years of dividends at six per cent. per annum upon the value of fifty millions of dollars of the capital stock of the Company. Mr. Eads withdrew his proposition from the further consideration of Congress. Limited by the concessions of Mexico to invoking the aid of only one foreign power, if the United States chose to refuse to be that one power, blindly against her own interest, no one should gainsay her that privilege. Work was begun at the Isthmus May 1st, 1883, and was to be completed within ten years. Captain Eads visited Europe during 1883, in the interest of his project. A recent article in the New York

*Sun* states that "the new models of the carriage and pontoons of the Eads Ship Railway have started for London. Nearly all the capital for the enterprise is being subscribed in that city. Chief Engineer Corthell says one hundred men are at work, and that the first half mile of track has been completed. This, with the river course, which admits three of the largest ships abreast, completes twenty-five and a-half miles of the Tehauntepec route. The new pontoon system of raising vessels from the water upon the railway carriage is to be substituted for the hydraulic system first contemplated. It was conceived by London engineers and adopted by Eads, and will raise a ship out of water and upon the carriage in twenty minutes."

The ship-railway, when completed, will shorten the route between two great commercial centres eight thousand two hundred and fifty miles in distance, and ninety days in time, and its value, its supreme necessity, will be apparent to every scientific and thinking mind, while its effect on commerce is almost beyond computation.

Captain Eads was formally invited to improve the harbor at Galveston, and secured the passage of a bill authorizing him to deepen the channel at that port. Though inimical engineers may not be wanting here to declare Captain Eads project incapable of performance, a backward glance at the Eads jetties, with their navigable depth of thirty-three feet where eight feet formerly existed, would seem to indicate that he was sufficienty indorsed.

A man who can crowd into a lifetime three stupendous achievements, any one of which would have made his name imperishable, is not to be judged by ordinary standards. Indefatigable and self-reliant, he was as staunch in his under-

takings as the granite piers of his own bridge, and as true to his purpose as the steel arches that clasp them.

In private life, Mr. Eads was kind and genial, easy of approach, and the dispenser of a bounteous hospitality. He was twice married, his first wife surviving their union only seven years. His second wife resides in St. Louis, and gracefully reflects the honors that so successfully crowned the last years of her husband's most useful life.

## THE RAILWAY ENGINE.

TO the unthinking man, a railway trip in this, the last decade of the nineteenth century, is a thing of little moment. Two parallel rails is, to him, the symbol of rapid and easy transit, and his sole anxiety is expended on the price of the railway ticket and the safe bestowal of himself in the carriage before the departure of the train. To the thinking man, this rapid and easy gliding through unknown and unnoted miles; this drawing by an unseen power through hours of darkness and of light; this compelling by immutable laws the unseen power to expend its strength and energy in the transportation from one point to another of any conceivable burden, becomes a miracle of inventive genius. Every revolving wheel and nut and screw, every rail with its fastenings, every valve and cylinder and piston is to him a point where ingenuity has centered and invention struggled. The journey he accomplishes in one hour, without exertion or fatigue, exacted from his forefathers a hundred years ago a day of wearisome and tedious travel. This triumph of mind over matter was achieved for him before he was born, not by a single stroke of omnipotent genius, but by steady and long-enduring anxiety and toil. From the work he turns to the worker; from the splendor of the achievement to the obscurity of the collier, whose persever-

GEO. STEPHENSON.

ance and patience made him the achiever. Nor could he contemplate a nobler character. As the first man who ever successfully constructed a locomotive engine and by his untiring and unyielding spirit forced its introduction and employment, we give to George Stephenson the homage due a benefactor. In the little colliery village of Wylam-on-the-Tyne, England, he was born June 9th, 1781. His father, Robert Stephenson, was fireman of the engine at the Wylam mine, and young George's earliest recollections were of the beat and play of this machine. Being, like his fellow-colliers, very poor, Robert Stephenson was unable to send any of his six children to school; but each contributed, when scarcely past the helplessness of childhood, to the general support. Sturdy and industrious, George's childhood passed in the performance of duties common to other colliery lads, till at the age of fifteen he was appointed fireman, and at seventeen engine-man at Water-rood pit, his father taking the inferior position of fireman to the same engine.

George now set to work to gain a thorough mastery over the machine intrusted to his care. It was his duty, if his engine became clogged or refused to work in any way, to call in the aid of the chief engineer. But so assiduously did he study his engine and pry into her secrets, he could soon determine the causes of her obstinacy, and these being removed, himself persuade her to renew her work. This puffing, noisy, busy engine became his pet. He laid his hand upon her throbbing pulse and felt the beatings of her mighty heart. He loosed the hinges of her gigantic limbs that he might find the secret of their strength; and, having found it, pieced her up again, caressed her into forgiveness of his pranks, and petted her into renewed activity.

In hours of leisure he made clay models of engines he had seen or heard described. The wonderful engines of Boulton and Watt had excited his curiosity to the highest degree, and he was anxious to have accurate "information as to their construction, action, and uses." He was told he would find such information in books; but alas! books were to him a sealed fountain. He could not read, even the letters being to him a series of hieroglyphics as meaningless as an Egyptian legend. For the first time the necessity of possessing some degree of education struck him with full force. The wisdom of ages had been deposited in books as coal in the bowels of the earth, and the art of reading was one of the picks with which he would be able to dig out the wisdom of others and make it his own.

To learn to read then was his instant resolve. He was eighteen, a man in size and strength and capacity for work, yet was not ashamed to become as a little child, acknowledge his ignorance, and begin at the alphabet. His wages were small, but he paid three pence a week to a poor teacher, Robin Cowers, of Walbottle, for the privilege of attending his night-school three evenings a week. After his twelve hours' hard labor at his engine he walked over to Walbottle and took lessons in reading and writing. So surely will the hungry mind push aside all obstacles to obtain its natural and necessary food. Public schools and compulsory education may be necessary to cram the many with unappreciated smatterings, but where there is a great and absorbing thirst it is in itself an unerring guide to some wayside fountain where one may drink to repletion. Though his teacher was but little more competent than himself, the strong will of George and his untiring industry soon enabled him read, and

in writing he advanced far enough to ascribe with pride his own name when he was nineteen years old. In the winter of 1799 he attended the night-school of Andrew Robertson, in the village of Newburn. He was induced to make this change partly on account of the proximity of the school to Jolly's Close, but more particularly because Robertson, having the reputation of being a good arithmetician, could give him instruction in this department of knowledge. His tuition fee was advanced to four pence a week for three evenings' instruction. He began battling with figures. In his spare moments during the day he sat down by his engine fire, not to rest, but to take his slate and solve the problems set for him the preceding night by the master. No shirking laggard was he, glad to evade or escape a difficult task. If anything prevented his attendance at the school, he sent his slate by a co-laborer and fellow-student to be filled with a new set of problems that he might not lose one single day in advancing himself in this intricate science. What an example of untiring industry and patience and unyielding purpose is this! If George Stephenson had never done anything else but leave to posterity this record of his student-life, this alone would have been worth to the world more than the records of thousands of men whose shoe-latchets he would not have been considered worthy to unloose.

But his pursuit of knowledge did not lessen his interest in his daily labor. Braking was the next step above engineering, and of this he determined to acquire a practical knowledge. In the intervals he could spare from his labors as engine-man, William Coe, his friend and fellow-workman, allowed him to take his place as brakeman, giving him the necessary instructions. He quickly acquired the art, and

when he went to Black Collerton in 1801, though only twenty years of age, he was appointed to the responsible office of brakeman to the Dolly Pit, and earned from fifteen to twenty shillings per week. Not satisfied with this remuneration, however, he added to it by mending, and afterward making, shoes during the evening hours. He levied a tax upon every moment of time, braking his engine, working the examples set for him on his slate, practicing writing in his copy-book, or making and mending shoes.

Naturally ambitious, industrious, and energetic, a new impetus had been given to these traits by an outside influence that came to bear upon his life. In the farmer's house in which he lodged was a young and handsome girl, whose personal charms were enhanced by the graces of her mind and heart, and it was not long before her charming modesty, her constant and unobtrusive kindliness, and above all, her strong and practical good sense, began to cast a potent spell over this young Hercules. Unaccustomed to sue, perhaps his wooing was something rough and homely, but it was manly and to the point, and secured from his charmer the promise which he sought. It only remained for him to secure a modest competency for their livelihood for the betrothal to consummate in marriage.

When twenty-one, Stephenson received an offer to take charge of an engine on Willington Ballast Hill, with increased wages. By thrift, industry, and economy, he had managed to lay by a sum sufficient to take a small cottage at Willington Quay, so he determined to accept the offer, and at the same time to take with him to the new scene of his labors his sweetheart, Fanny, to be the constant light of his heart and home. They were married in Newburn Church,

November 28th, 1802, and George carried his young bride down to Jolly's Close, where "Old Bob" and his wife, Mabel, still lived. After this, they started for their bridal home at Willington Quay, distant fifteen miles, on horseback, the groom in the saddle, and his young wife on a pillion behind him, her arms encircling him for support.

Steadily working at his engine all day, George now began to look beyond its mechanical parts, and try to solve the laws that compelled its working. During the winter evenings, he was engaged in studying mechanical laws, or in modeling experimental machines. He was caught by the mirage of Perpetual Motion, and though after patient toiling, he discovered its fallacy, his powers of acuteness and invention were whetted by the exercise.

On October 16th, 1803, was born George's only child, Robert, and this little problematic bundle of humanity became a new source of speculation and inquiry.

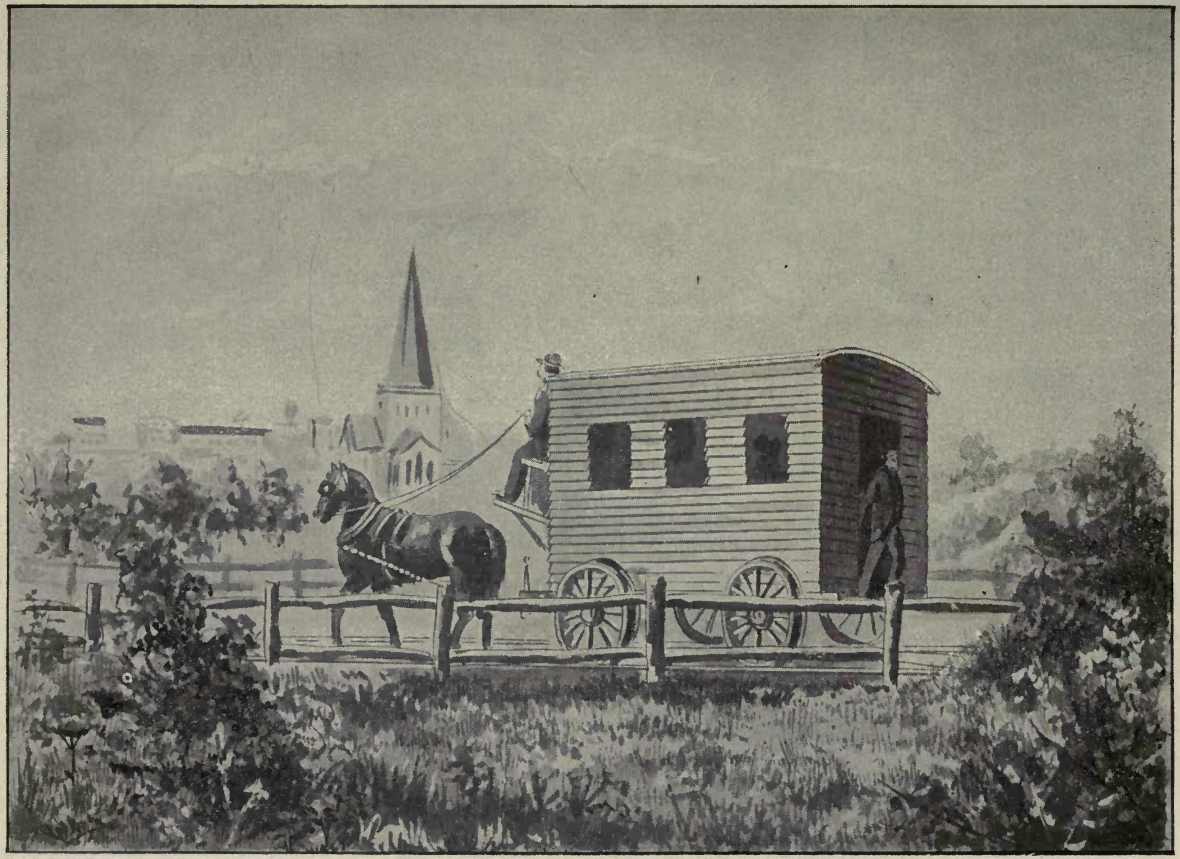
In 1804, Stephenson became engine-man at the Killingworth mine. It was near the close of the year when they moved to their new home, but for one of them it was but a temporary abiding-place. His wife sickened and died, leaving to him an embodied memory of herself in little Robert.

While this deep wound was still bleeding, he received an invitation to go to Scotland, to superintend one of the Boulton and Watt engines in some spinning works near Montrose, an offer which he immediately accepted. His duties he thoroughly understood, and he was well paid, but at the end of the year he returned to England, only to find new sources of anxiety. In an accident, his father had suffered the loss of his eyesight, and it required half the twenty-eight pounds George had saved to cancel the debts of the family.

Other troubles harassed him. Napoleon was shaking the world with his tread. England was calling for recruits. Scarcity of work and lowness of wages had engendered bitter discontent, which had already produced riotous upheavals at Manchester, Newcastle, and elsewhere. The working people were being pressed for the navy, or drawn for the militia, and among this latter class was George Stephenson. With the responsibility of the support of his parents and the care of his motherless boy resting upon him, he determined to hire a substitute. The remainder of his hardly-won earnings, with six pounds of borrowed money, procured the substitute, but left him penniless and disheartened. His sister and her husband emigrating to America about this time, he all but resolved to go with them, but was deterred by lack of funds.

As he was too poor to get away from England, the next best thing was to go immediately to work, at the best wages he could secure. He, with two other brakemen, took a small contract for braking the engine at West Moor Pit. The average earnings of each amounted to eighteen or twenty shillings per week, and Stephenson soon set his ingenious mind to work to make the contract pay better. By an entire rearrangement of the gearing and shifting of the pulleys, he lessened the friction, so that the ropes lasted longer, and the men were enabled to work more continuously and profitably.

In 1810, a Sweaton engine was fixed at the High Pit, to pump the water out of the mine; but being defective, she worked fruitlessly for twelve months. One Saturday afternoon, after a thorough inspection, Stephenson concluded he could remedy her defects; and being invited to try by Mr. Dodds, the head-viewer, ingeniously altered the machinery,



THE FIRST RAILWAY CARRIAGE.

and in three days the mine was clear of water. In recognition of his ingenuity, Stephenson received ten pounds, and was appointed engine-man at the High Pit.

In 1812, Mr. Dodds showed his appreciation of Stephenson by recommending to the company that he be appointed enginewright of the colliery; and they, having heard of Stephenson's skill and marked intelligence, put the position into his hands with a salary of one hundred pounds a year.

Rising rapidly as he was in the grade of labor, he never for an instant relaxed his energies in the pursuit of knowledge. Snatching a leisure moment from his engine, with pencil and slate, or chalk and a wagon-side, he kept chasing the secrets of mathematics. Feeling deeply the want of early school-training during his own childhood, he determined that his son should not suffer a like deprivation, though it might require strictest economy and constant self-sacrifice on his part to procure the money for his tuition. So he made and mended shoes, cleaned clocks and watches, cut out the pitmen's clothes, and this in the evening hours when his hard day's toil was done.

In 1815, his son Robert, having attained to the required age, was sent to Newcastle to school, riding back and forth morning and evening. In the evenings the son taught the father what he had learned during the day. Sometimes he brought home a book from the library, when father and son were to be seen poring over its pages together.

His inventive faculties began now to exhibit their activity in different ways. He constructed an alarm to the clock of the watchman that the pitmen might be called with unerring regularity, made the babies' cradles self-rocking by attaching them to the smoke-jacks, and fished at night with a lamp that

burned under water. He procured a Ferguson's *Astronomy*, made the necessary calculations as to latitude, and made a sun-dial. He constructed a self-acting incline so that the full wagons descending drew the empty ones up the slope. He made improvements in the engines above the ground, and descending into the mines by using the surplus strength of one engine, he reduced the number of horses from one hundred to fifteen.

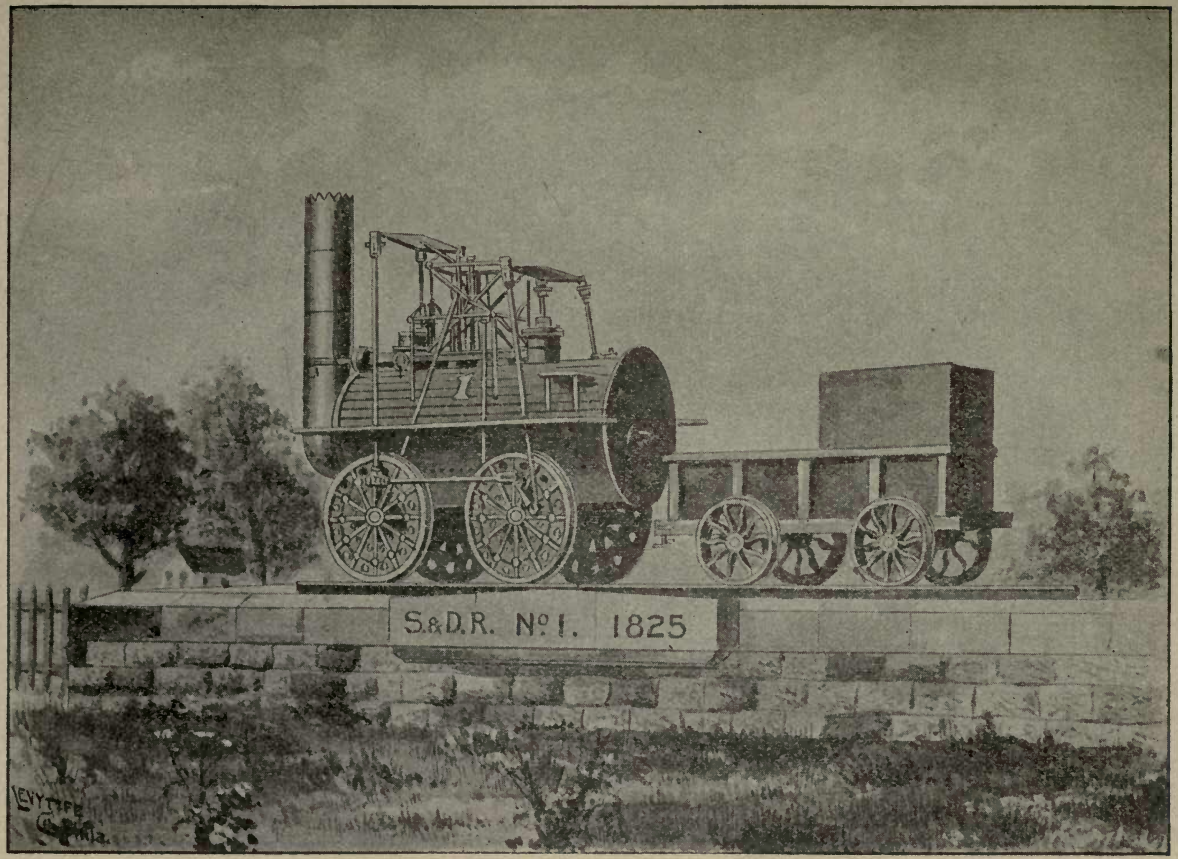
The coals of the Killingworth mine, to be shipped, had to be dragged by horses three miles to the Tyne. George Stephenson had set himself to solve the problem of more economical portage, both as regarded time and money. Blenkinsop and Blackett had both tried the haulage of coals with locomotive engines of their own construction and had both failed. Stephenson thought he saw the causes of their failure, and planned an engine which he wished to try. He brought the subject before the lessees of the mine in 1813, and Lord Ravensworth, one of the partners, advanced the money for the construction of the locomotive. It was built in the workshops at the West Moor, with rude and clumsy tools, and by ruder and clumsier men. After ten months' hard labor and anxiety, it was completed, christened "Blutcher," and placed upon the Killingworth road, July 25th, 1814. On an ascending gradient of one in four hundred and fifty the engine succeded in drawing five loaded carriages of thirty tons weight at four miles an hour. Not satisfied with his success, Stephenson set himself diligently to improve on "Blutcher," and accordingly in 1815 was granted a patent for another and far more economical engine, one in which steam-blast was for the first time applied.

Stephenson's mind, however, was not wholly occupied with

locomotives. Wherever he saw the necessity for an invention his mind at once seized with avidity that point and never left it. One day in 1814 a workman rushed into his cottage with the startling intelligence that the deepest main of the colliery was on fire from an explosion of fire-damp. Pushing his way through terror-stricken groups of women and children, he ordered the enginemen to lower him at once into the mine. He was soon in the midst of the pitmen, huddled together at the bottom, panic-stricken at this sudden apparition of a frightful death.

"Are there six men among you who have the courage to follow me. If so come, and we will put the fire out." Smitten into sudden silence by a voice so full of moral and manly courage, six followed where Stephenson led into this "mouth of hell," and following his example, fell quickly to work and stopped with stone and mortar the mouth of the burning shaft. "Can nothing be done to prevent such awful occurrences?" asked Kit Heppel. "I think something can be done," was the quiet reply of Stephenson, this master-thinker, who was already searching about in the darks and depths for that something to do. "The price of coal mining is pitmen's lives" was the axiom with which he began the problem, and in the autumn of 1815, though his whole soul seemed absorbed in the improvement and successful employment of the locomotive, he had evolved the solution out of his own mind. Late on the evening of October 21st, he received from the Messrs. Hogg, tinmen, a safety-lamp made according to his instructions, and immediately proceeded to test it in the most dangerous part of the mine. Owing to unavoidable delay, it was near midnight when Stephenson, accompanied by his two friends, Moodie and Wood, descended into the mine with the

lighted lamp. To make this an effectual and perfect test of his lamp, Stephenson erected a sort of chamber by walling in that part of the gallery into which the gas was escaping, so that the air would be most foul for the purpose of experiment. After an hour's waiting Moodie, who had the greatest experience in fire-damp, was sent into the chamber, and returning, declared that if a lighted candle were now introduced into this poisoned hole an explosion would be inevitable. The two others tried to dissuade Stephenson from risking his life by entering the gaseous chamber with his lighted lamp. They retired to a place of safety, and Stephenson, alone at this midnight hour, walked calmly into the dismal and reeking cavern, holding in his firm right hand his untried lamp, which, if unsuccessful, must prove to him the inevitable messenger of death. The flame brightened, then flickered, then went out, leaving Stephenson to grope his way in darkness back to his anxious friends, triumphant in his victory over the fiend of the mines. This was the first practical safety-lamp ever invented, and was tested in the mines October 21st, 1815. A second and improved one was tested by Stephenson on November 4th, and it was not till November 9th of the same year that the safety-lamp of Sir Humphrey Davey was exhibited to the public, and by the 30th of November Stephenson had constructed his third safety-lamp. Each, working independently and in ignorance of the other, had arrived at the same issue. Sir Humphrey had worked downward from a scientific stand-point to the poor miner in the death-dealing mine. Stephenson, himself inhaling the poisonous gases in the dim-lighted caverns, had worked upward from the broad level of humanity to this sublime height of life-saving thought. Sir Humphrey was presented with two thousand




NO. 1 ENGINE AT DARLINGTON.

pounds. Stephenson, from his friends, one thousand, and from the poor colliers a plain silver watch, which to the day of his death, he declared was the most highly prized gift of his life.

Meanwhile his locomotive engine was daily performing its work on the Killingworth road, though Stephenson regarded it as far from perfect, and was daily studying its improvement. He and Mr. Lost, the iron-founder, secured a patent for an improved manner of laying the cast-iron rails, and he changed the wheels of his locomotive from cast to malleable iron, making them more durable and safe. These identical engines constructed by Stephenson in 1818 were still in use on the road in 1865. But Killingworth Colliery lay far from London, the centre of scientific life, and Stephenson, while the fires of originality burned hotly within him, could not give vent to his thoughts or describe his inventions in treatises and pamphlets, since in his early life he had not had time to acquire any mastery over written language. So much was he in despair of being able to bring his locomotive before the public that the old idea of emigrating to America began to haunt him. Fortunately, however, about this time the owners of the Hatton Colliery determined to alter their wagon-way to a locomotive railroad, and invited Stephenson to act as engineer of the line. This was in 1819, and on the 18th of November, 1822, five of the Stephenson locomotives were at work upon this railway, each capable of drawing seventeen wagons weighing sixty-four tons at the rate of four miles an hour.

While this work was being carried on by Stephenson, the question of a railway between Stockton and Darlington was fiercely agitated. Edward Pease had put his strong shoulder

under the scheme, and was pushing it forward against bitter opposition. Toward the close of 1821 Nicholas Wood and George Stephenson called on Mr. Pease, Stephenson introducing himself, in his strong Northumbrian dialect, "as only the enginewright at Killingworth." The object of this visit on the part of Stephenson was to make application for the position of engineer on the contemplated Stockton & Darlington railroad. The honesty and intelligence of the enginewright so impressed Mr. Pease that he immediately instituted inquiries about Stephenson, and these were so satisfactory that the appointment was forthwith given to him.

Mr. Pease, however, was in favor of stationary engines as the tractive power, till, being invited by Stephenson to take a ride on one of his Killingworth engines, he was so impressed with the powers and capabilities of the locomotive that he became at once its declared supporter.

September 27th, 1825, the road was formally opened, having been in course of construction for three years; the "Experiment," the first passenger coach ever built, and devised by Stephenson, forming part of the procession. The locomotive engine was driven by Stephenson himself, and drew after it at a continuous speed of four miles an hour twenty-two wagons, containing passengers, directors, and proprietors, and twelve wagons loaded with coal and flour.

In 1821, the merchants of Liverpool and Manchester began to consider the expediency of bringing these two centres of commerce and manufacture into more direct communication. A tram-road was first contemplated, but Mr. James, the surveyor of the line, having seen the Stephenson locomotive in operation, advocated a railroad instead. As the survey of the line proceeded, Mr. James, becoming em-

barrassed with private debts, of which he was unable to free himself, the railway committee found themselves obliged to secure another engineer. The energy and practical ability Stephenson had displayed from the initiation of the Stockton-Darlington scheme up to the moment when this scheme was approaching its completion, pointed to him as the fittest man for the undertaking. Stephenson effected the survey under an accumulation of opposition from land-owners and peasantry. Sometimes by strategy he outwitted them, sometimes by night he stole along past his sleeping enemies.

The bill entered the House of Commons March 21st, 1825. Before its reading, when Stephenson stated to Wm. Brougham, one of the retainers to defend the bill against known opposition, that he confidently expected to run his locomotive at the rate of twenty miles an hour, this gentleman told him if he did not moderate his views and bring his engine within a reasonable rate of speed, "he would inevitably damn the whole thing, and himself be regarded as a maniac fit only for Bedlam."

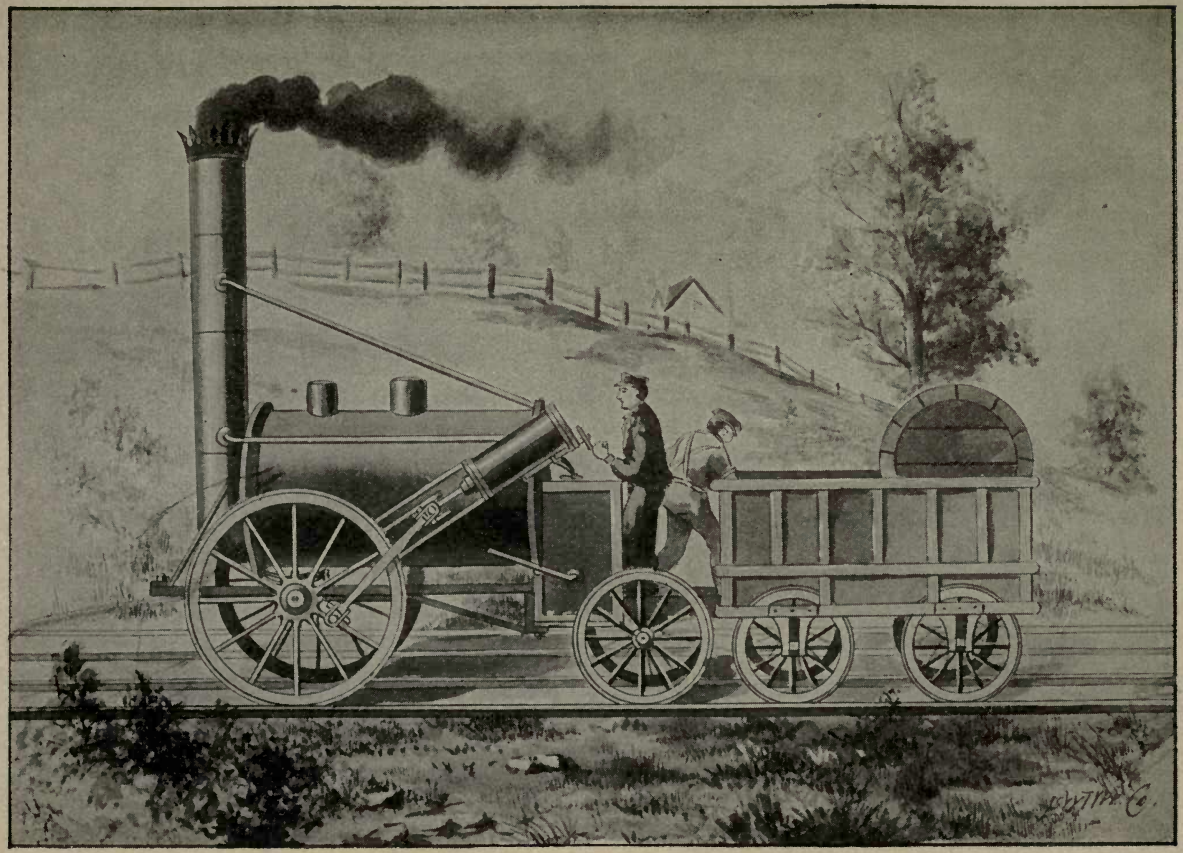
On March 25th, Stephenson was called into the witness-box to demonstrate that which men of sense and science everywhere declared to be impossible. In the midst of sneers, interruptions, and ridicule and whispered doubts as to his sanity, Stephenson stood by his locomotive with a firmness that amounted to heroism. But this "unlettered, inarticulate genius" had no power to force his reasoning in upon the thick heads of these lawyers, who did not know one part of an engine from another. The contest lasted over two months, but the bill was finally defeated. This was the severest trial that had ever befallen Stephenson. He had fought for the bill almost single-handed, had been stigma-

tized as a fool, an ignoramus, and a maniac, had seen his friends look doubtfully upon him and his locomotive, and now the railway committee informed him they thought it best to release him, and employ scientific engineers for a second survey.

The bill again went into Parliament March, 1826, and was carried, and Stephenson was appointed chief enigineer, at a salary of one thousand pounds per annum. The line was completed and formally opened to the public September 15th, 1830. In these four years, the busiest of his busy life, Stephenson had finished this gigantic undertaking; had personally superintended the construction of the entire thirty miles; had planned and built sixty-three bridges, including the famous Sankey viaduct, which consists of nine arches, each of fifty feet span; had cut through the solid rock of Olive Mount a narrow track two miles long, and in some places one hundred feet deep; had tunneled his way for a mile and a half under Liverpool; and had successfully laid his iron rails across Chat Moss, an impenetrable bog, twelve square miles in extent, a feat which the lawyers in Parliament had unanimously declared impossible.

During the ceremonies of the opening day, an unfortunate accident occurred, in which Mr. Huskisson fell under the train and was badly crushed. George Stephenson conveyed the wounded man on his train to Eccles, a distance of fifteen miles, in twenty-five minutes, or at the rate of thirty-six miles an hour. This was the fool, the ignoramus, the maniac, asserting his right to the title!

Fifty years afterward, on September 7th, 1881, another wounded man, the stricken chief of a nation, was conveyed by railway at a velocity at times almost doubling that made



THE ROCKET.

by Stephenson. This road was a branch of the Pennsylvania system, which uniformly makes between Philadelphia and Pittsburgh over forty miles, and between Philadelphia and New York forty-nine and a half miles per hour. The New York Central, another great net-work of railways that has spread rapidly since Stephenson first accomplished their introduction, has, between Buffalo and Albany, a running speed of sixty miles an hour. In Stephenson's own country, the Great Northern Railway has a uniform velocity of forty-seven, and this is frequently increased to sixty-two miles an hour; while short runs from London are daily made at an average velocity of seventy-three to seventy-eight miles an hour. If, as Emerson says, "Every ship that comes to America gets its chart from Columbus," then every locomotive that shrieks and pants its busy way from place to place "borrows the genius" of Stephenson.

Such speed as Stephenson had attained in his fifteen-mile run to Eccles became everywhere the subject of excited speculation. Those who had sneered at the locomotive acquiring the speed of a mail coach, now went to the other extreme and declared that the rapidity with which it could be driven might be extended to fifty, sixty, or a hundred miles an hour. But Stephenson had grappled with the locomotive too long to be led captive by a vision of unnecessary velocities. While practically there might be no limit to the rapidity which might be conveyed to the wheels by the motive power, such rapidity must always be governed and limited by the strength of materials. A locomotive and road-bed that could safely stand a speed of twenty miles an hour, would, if the speed were increased to forty or fifty miles, be inevitably

torn to pieces. As a high rate of speed engendered danger and was practically unnecessary, he thought railroad projectors ought to keep themselves within the limits of safe locomotion.

While these discussions as to speed were rife, wild speculations as to the remuneration to be gained from railroads seized the country. New railway schemes opened up every day, many of which were shameful frauds. Gambling in railroad stocks became a mania, and the more prudent ones that refused to enter the vortex were said to be shamefully neglectful of the interests of their families. Shares were bought and sold as the railway beam rose or fell, and many were the victims to the sharpers that controlled the market. From all this Stephenson held aloof. He refused to indorse any of these schemes, and constantly warned others away from them. If thoroughly convinced of the solidity of a railroad project, he sometimes bought shares, but held them, however much the market fluctuated, being restrained by principle from this species of gambling.

Not only in England, but in foreign countries, wherever a railroad was contemplated, Stephenson was besieged for his advice. In Belgium he was honored by a magnificent banquet, and King Leopold invited him to a private interview to get his opinion in regard to railways, and the development of the coal fields of his kingdom. His correspondence with railway projectors and inventors was so great he employed a private secretary, to whom, in one day, he dictated thirty-seven letters.

In 1820, Stephenson had remarried a lady of most estimable character, and to whom his son was devotedly attached. He had settled at Alton, but afterward removed to Tapton,

where the closing years of his life were spent in the bosom of his family in the quiet enjoyment of his dogs and rabbits, his birds and fruits and flowers.

Sir Robert Peel was a warm friend and admirer of Stephenson, and invited him to his house at Drayton, where the vigor of his thought and the originality and shrewdness of his observations charmed all who came within his circle.

In the spring of 1848, Stephenson was invited to Whittington House to meet the distinguished American, Emerson. In speaking of this visit, Emerson afterward said, "It was worth crossing the Atlantic were it only to see Stephenson—he had such force of character and vigor of intellect."

In August, 1848, he was seized with intermittent fever, and after an illness of ten days, while all thought him recovering, suddenly died from an effusion of blood from the lungs. He reposes at Trinity Church, Chesterfield, where a simple tablet marks his resting place.

A statue of Stephenson, ordered by the Liverpool & Manchester and Grand Junction Companies, stands in St. George's Hall, Liverpool. Another, erected by the Society of Mechanical Engineers, stands in the vestibule of the station in Euston Square, London. But the finest statue of him is to be seen at Newcastle in a very thoroughfare of workingmen, close to the smoke of the great locomotive foundry established by himself, and under the shadow of the High Level Bridge, erected by the genius of his son.

## THE MORSE TELEGRAPH.

WHILE we listen with wonder to the demands of electricity for new avenues in which to exhibit her strength and utility, we turn with greater pleasure to the story of no man than to his whose genius first caught the "winged fire" and bade it bear his thoughts in its swift flight to some distant point. To Samuel Morse, the profound scholar, the indefatigable worker, and triumphant inventor, we accord this honor. He it was who first demonstrated a practical method for the transmission of messages through the agency of electricity, a force hitherto familiarly known only as a divine smile playing about the face of some angry storm-cloud. Others had been tampering with this spirit-fire as it came and went in its noiseless way like a ghost, manifesting its presence by a shock that thrilled every fibre of their beings, or else startling them by a spark that instantly vanished. But Morse breathed his thoughts into its current, and bade it deliver them to whomsoever he willed. This most distinguished scion of a distinguished family, Samuel Finley Breese Morse, was born April 27th, 1791, in Charlestown, Mass. His father, Jedediah Morse, himself a sturdy and practical thinker, compiled and published the first geography ever printed on this continent. With a vigor and energy that were but strengthened by difficulties, he labored

on his work of gaining correct statistics and surveys during the week, and on Sunday, in the pulpit, he devoted the day of rest to the religious instruction of the people. Well for us he bequeathed to his eldest son his powers of concentrated thought and the ability to reduce to practical ends the vague dreams of the philosopher.

His brother, Sidney, three years his junior, was a brilliant, precocious lad, who, while other boys were playing with their marbles and tops, was publishing political pamphlets showing the danger accruing to the new Republic from the multiplication of States. Afterward a learned and logical divine, perhaps he is best known to the world as the founder of the *New York Observer*, a religious paper that has enjoyed the widest circulation of any paper of like character published in America.

Samuel was rugged and healthful, fond of boyhood's sports and staunch as the hills he climbed. Saved from a hand-to-hand fight with poverty by the money his father had realized from the publication of his geography, he was enabled to prosecute his studies uninterruptedly at the district school. This he did so successfully under his father's guidance that, at the age of fifteen he was enabled to enter Yale College. Here, unlike so many youths who become distinguished men, he did not trust to the flashes of his genius to light him over the obscure and difficult road through which knowledge leads her votaries, but by intense and methodical study made himself master of each day's allotted work. Here we catch a glimpse of that intellect which was being nurtured and trained for that work that was destined to be its ultimatum. Thoroughly analytical and penetrating, we find him one day triumphantly unravelling some mathematical intricacy, and

declaring himself ready to adopt civil engineering as his life-work. The next, fascinated by the wonder-working laboratory, this young enthusiast barely escaped blowing himself and his comrades into atoms by the rash combination of antagonistic elements. Again, fascinated by some paintings that come under his notice, he falls in love with Art, and declares henceforth she alone shall be his mistress. Meanwhile, having graduated with some distinction, after three years of college life, he is urged by his practical father to turn his whole attention to civil engineering as being an honorable and most lucrative calling. But his new love was too strong and absorbing. He had stood before the canvases of Allston and West and longed only for a palette and brush. He quietly held his own against not only the wishes but the ridicule of his father, and in the year following his graduation, as the *protégé* of Allston, he embarked for London to make formal entrance into the world of art. The sturdy good sense of the father supplied him with money to begin his career, but it is not to be doubted that he did so on the principle that if he had rope enough he would hang himself; and flattered himself that New England hills would soon welcome back the ambitious and impecunious prodigal, who would gladly enough turn to some more practical and money-making occupation.

Allston presented him to Benjamin West, who was charmed with the young and enthusiastic student, and it was under the guidance of these two celebrated painters Morse began his art studies. His warmth of heart and fine social qualities soon won him such friends among eminent artists as Fuseli, Northcote, Turner, Sir Thomas Lawrence, Flaxman, and others, while his quick intelligence and healthy tone of mind

attracted to him such congenial spirits in the literary world as Coleridge, Wordsworth, Rogers, Crabbe. Those same habits of method and industry that had characterized the Yale student, also distinguished him as an embryro artist, and in one year from the time he went to London, we find him at work upon so pretentious a subject as the "Dying Hercules." Having first made a clay model of his hero, he placed it on exhibition, and had the honor of receiving the prize offered by the Adelphia Society of Arts, though there were thirteen other competitors. This was a triumph, indeed, and inspired him to compete for the prize of the Royal Academy in historical painting, though the subject was so severe a one as "The Judgment of Jupiter." Benjamin West, President of the Royal Academy, pronounced the highest eulogies upon the finished picture, and expressed the opinion that it would have drawn the prize had it not suddenly been withdrawn from the contest a few months before the time of decision. But poverty, that grim and relentless arbiter of our fates, rudely awoke the young artist from his ambitious dreams, showed him his pockets as empty of coin as his larder was empty of bread, and drove him unmercifully from the scene of his expected triumph. He returned to America and set up his studio in Boston, and adorned it with many beautiful works of art, both original compositions and copies of the work of others. But, while many admired, none gave him an order for a picture, and his finances soon became so low that he was compelled to leave Boston. He went to Concord, abandoned historical painting, and advertised to paint portraits at ten dollars apiece. But few people cared to see themselves on canvas, and he did not receive orders

enough to make a fair living. Long ago Allston had filled his mind with glowing pictures of the South, and of Charleston, his home, as being the centre of refinement and æsthetic taste, and thither he determined to go in search of better fortunes. He bore with him the inspiration of a warm attachment that had sprung up between him and a young lady in Concord, and the hope of a marriage with her stimulated him to wonderful industry in his new field. All that succeeding winter and spring we hear of him painting four portraits a week, for which he was paid in this wealthy city of Charleston sixty dollars apiece. In one year he returned to New England with three thousand dollars, and on the 6th of October, 1818, was married to Miss Lucretia Walker, his gentle and faithful sweetheart. Four successive winters he painted portraits in Charleston, and then settled in New Haven and once more returned to historical works. His first study was the "Interior of the House of Representatives," introducing in miniature the faces of the most distinguished Congressmen; but as he had to pay one hundred and ten dollars for the privilege of placing his picture on exhibition in New York, it was with no small degree of chagrin and disgust that he rolled up out of sight a work that had cost him nearly two years of severe labor. He now removed to New York induced greatly to make this change by the fact that his brother, Sidney, had already founded the *New York Observer*, and was its successful editor. Here he painted when he could find a subject willing to be painted; delivered lectures on art and taught a class of four young men, to obtain money sufficient to support himself and family, for he had now three young children. That he did paint well is attested by the fact that he was commissioned by an

assembly of New Yorkers to paint the portrait of Lafayette, just arrived in this country. So great an honor rarely befell him, and he brought to his task not only a genuine love of his art, but an enthusiastic admiration of his subject. While engaged on this delightful work he was suddenly called to the bedside of his young wife, and ere his return he had borne both her and his father to their eternal resting-places. He was almost heart-broken at his bereavement, and the eulogy upon the stone that marks the grave of his wife we may well believe to be a genuine expression of the deep and lasting love he bore her. With a heavy heart he completed the task so sadly interrupted. Lafayette was delighted with both picture and painter, and William Cullen Bryant formed an attachment for the young artist which lasted through life.

Meanwhile the signs were growing ominous that the birth of some great invention in the electrical world was about to startle the universe. When Morse laid aside his palette, it was to seek recreation in experimenting in chemistry and in discussing with Dana, his life-long friend, the wonderful phenomena of electricity and electro-magnetism. His keen interest on this subject was remarkable.

It was during this period that Morse was reduced to great poverty. One day he acknowledged to one of his pupils that he had not tasted bread in twenty-four hours. But having sworn allegiance to Art, he would not abate his worship, though he had been obliged to confess she had become indifferent to his wants and suffering. Centering the secret of his failures in himself, and excusing the coyness of his chosen mistress, he determined if possible to go abroad again, and by hard study acquire such a mastery over his

art as would enable him to gain not only a livelihood, but affluence and renown.

In 1829, he carried his wishes into effect, and for the second time trod European soil. He visited the principal art galleries of Europe, and with that love of analysis so eminently his characteristic, he tried to wrest from the celebrated paintings the secret of their fascination. Why such groupings of proportions, and such blendings of color should produce certain effects he labored to ascertain, that he might reduce to a system of laws the art of painting, and so be able to reproduce at will such exhibitions of beauty and grandeur as now seemed beyond his reach. Alas! Beauty is a law unto itself and in whatever form appearing is its own best apology for existence. He made many warm friends during this tour, notably among these being Arago, the astronomer, and Humboldt.

In October, 1832, Morse turned his face homeward, with his brain crowded with impressions, and ready to give to the world on canvas the result of his three years' hard study. What that result might have been we can only conjecture. He had sailed on the packet ship "Sully," little dreaming that this was to be the birthplace of an idea from his own brain which should afterward practically annihilate time and distance. The world was ripe for the invention. Savants in widely different sections had been experimenting in electromagnetism. Œrsted, of Copenhagen, had established the correlation of electricity and magetism. Conversation everywhere turned upon this subject and the wonders yet to be. On board the "Sully" a gentleman was describing how he had recently seen sparks drawn from a magnet.

"How long does it take the fluid to pass through one hundred feet of wire?" asked a passenger.

"It passes instantaneously," immediately answered Morse; "and if that is so," he continued slowly, his mind turning in upon itself, "and electricity could be made to manifest itself at any part of the circuit, I see no reason why messages could not be transmitted instantaneously by electricity."

This remark was greeted by a smile of incredulity, but while the others remained to jest, Morse, with pencil and paper, shut himself up to deep and exhaustive thought. What an agony of mental labor the little state-room must have witnessed before this child of his brain could assume practical and definite shape! And yet, before the "Sully" had dropped her anchor in New York harbor, the artist hand had sketched not a fanciful creation, but the outlines of an apparatus which, by a shock, was to bring the civilized world into instantaneous communion. But Morse was not destined to step from the deck of the "Sully" at once into glory and wealth. Science is no rewarder of light toil, but exacts from her devotees Herculean labor and a God-like patience. Three years passed, years to Morse of indefatigable labor, of exhaustive experiment, of infinite patience, and unquenchable zeal. At the end of that time Morse had constructed a rude instrument, with a half-mile of wire strung around his own room, and this transmitted only in one direction. Two years later he had improved upon this, and could both receive and transmit messages by the use of two instruments, one at either end of the wire. This he exhibited to his friends in his room at the University, who received it enthusiastically. Alfred Vail, both pupil and friend, became fascinated with the enterprise. The "Morse" machine was specially imperfect in its capacity for registering a message. "A pendulum motion compelled the register to make only one kind of marks,

a succession of v's, which could be varied only by increasing the interval between them or by inverting them." Alfred Vail at once set about devising an improvement on this method, and it was to his ingenuity that Morse was indebted for the invention of the "horizontal lever motion to actuate a pen," and also, as a natural sequence, the telegraphic alphabet. Vail also devoted his personal services and skill to the entire mechanical reconstruction of the Morse machine, and induced his father and brother to advance to Morse substantial means to enable him to demonstrate the adaptation of his invention to practical and useful ends. Morse had long since ceased to paint, and was now entirely dependent on the generosity of friends to finish the glorious enterprise which had absorbed him.

In 1837, he took his invention to Washington, filed a caveat for a patent and petitioned Congress for an appropriation of thirty thousand dollars to build an experimental line from Washington to Baltimore. The reading of his bill was listened to with grave earnestness, but the session closed without its being acted on. This was a bitter disappointment to Morse. Six long years had passed since he had struggled in the cabin of the "Sully" to place his original thought into drawings and words; six years of unremitting labor, of baffled hopes, of bitterest trial and disappintment; and now, since he had failed in securing an appropriation, the hour when he would be able to present his ideal instrument to the world seemed withdrawn to an interminable distance. People everywhere believed the telegraph to be but the fantasy of an idle dreamer; and Morse, thoroughly abandoning every other pursuit, fought with all the energy of his nature by pen and speech to maintain the utility of his

invention. A weaker man would have succumbed to the difficulties that thickened about him. Just at this time, too, as though Fate had reserved its heaviest blow for the last, it was announced that Steinheil, in Bavaria, and Wheatstone, in England, had separately laid claim to the invention of the telegraph. Denied at home the means to perfect an instrument, which should bring to his country not only renown, but also revolutionize her industrial and commercial pursuits, he was forced to witness two foreign claimants, aided by their more generous governments, seizing the prize for which he had so long struggled. Conscious of his own integrity in laying claim to the invention, he determined to go to Europe and fight Wheatstone on his own ground.

He had no trouble in proving the priority of his invention by four years, and its superiority for all practical purposes. Steinheil, with the noble generosity of true genius, at once declared the superiority of Morse's machine, and later on, when it became necessary to adopt some uniform system of telegraphy in Germany, he advised the adoption of Morse's invention. Morse then applied for a patent in England, but was denied this because some description of his invention had been published in a London magazine. He went to France, secured a patent, and she, with munificent generosity, bestowed on him her *brevêt d'invention*, and this to a man whose present and overwhelming need was money to push forward to its completion the grandest triumph of the nineteenth century. He returned to England, and might have secured a patent by special act had he waited, but there was pressing need that he should be at home to again seek an appropriation from Congress. Hope trailed her wings in the dust, but his dauntless spirit was as fiercely determined as ever to con-

tinue the struggle to the death. Once more his commanding figure was to be seen in the halls of Congress, the face somewhat worn and weary-looking from the fierce alternations of hope and despair, but the dark eyes as gloriously bright as of yore.

Congressmen exercised their wits at his expense and amended his bill by making it include a line to the moon, and pay for experiments in witchcraft, Millerism, and mesmerism. The reading of his bill was but the signal for a running fire of quips and jokes, the dullest member in the House feeling himself called upon to contribute his small share of ridicule under such provocation! And this, be it said to the everlasting shame of those who are supposed to represent the intelligence of the American people, was the recognition they gave to a man who had already demonstrated to the satisfaction of scientists the practicability of his invention! Had not his refined and sensitive spirit been upheld by a faith as sublime as it was unshaken, this continued defeat and heartless persecution must have proved a death-wound. Four long years passed thus, till at last the spring of 1843 dawned upon the earth.

The profound stillness of mid-winter was being stirred by wild March winds. The Congressional session must close on the 3d inst. Morse was there in his old place, his iron soul nerved to hear the fate of his bill. He had firmly resolved that should he fail in securing an appropriation he would turn to other channels to seek the money he so much needed. To Morse, seated in the gallery, the long hours of the afternoon session were slow torture. Bills were read, discussed, passed or defeated. Morse sat alone, the agony of suspense giving an added brightness to the dark eyes

gleaming in the pale face. None knew the intensity with which he listened to the reading of his own bill with its absurd amendment of a line to the moon. It was hoping against hope that it could have any other fate than that which had awaited its reading in past years. The same old round of ridicule, the same old jokes repeated with greater vehemence greeted its presentation. Trembling with emotion, Morse arose and left the House. Having retired to his hotel he sat down and gazed sadly out upon the March landscape, now darkened with the shadows of evening. Well might he have said with his admired and beloved Coleridge:

"———Winter slumbering in the open air
Wears on his smiling face a dream of Spring,
And I, the while, the sole unbusy thing,
Nor honey make, nor pair, nor build, nor sing.
* * * * * * * * *
Bloom O ye amaranths, bloom for whom ye may,
For me ye bloom not! Glide, rich streams, away!
With lips unbrightened, wreathless brow I stroll!
And would you learn the spells that drowse my soul?
Work without hope draws nectar in a sieve
And Hope without an object cannot live!"

But the brave Morse did not permit the dark pinions of despair to close aroud him; he sat down to think! Money he must have. How to get it, that was the question. If ever a time came in his life when he might have looked back and regretted that he had not made civil engineering his profession, that time must have been now; for if less congenial to his tastes that at least was the most lucrative. But it was not like him to look backward, but forward. What could he do in the immediate future that would pay? He was done with asking assistance at the hands of his unwilling countrymen. Thirty thousand dollars! It was a big sum and seemed

now to swell to impossible proportions. He looked at his right hand. It had been long since it had held a brush. Could it relearn that facile touch and mystic grace of the painter's art? He had sat so long at the feet of Science, would it be possible for him to win favors from his old sweetheart? She had been at best but an indifferent mistress; could he hope, being so long forsaken, she would not turn away altogether from his earnest pleading? He was not long in making his resolve. The money must be made by his own industry, and his industry would be best exerted in portrait-painting. Portrait-painting with its uncertain and wavering remuneration would take years to climb to the height of thirty thousand dollars. But with an iron will that knew "no variableness nor shadow of turning," he could transcend the almost impossible. The resolve once taken, a feeling of relief was instantly visible in the face of Morse, replacing the haggard look it had so long worn, and with a patient smile, pathetic in its absolute relinquishment of all past hopes, he set about packing his valise, preparatory to his return to New York in the morning. This done his weary head sought its long-needed repose. "Tired eyelids" soon sunk upon "tired eyes." "Sweet sleep," for many nights a stranger to his pillow, came "down from the blissful skies."

March 4th, 1843, dawned brilliantly upon Washington City, but nature, ever careful of her children, still kept Morse in the healthful embrace of sleep. When at last he awakened, it was to learn that a lady desired to see him. Descending to the parlor, Miss Ellsworth, the daughter of the Commissioner of Patents, came forward to greet him, an exuberant gladness in gesture and voice. Placing both her

hands in his, her bright face glowing with expectancy, "I have come to congratulate you, Professor Morse," she said.

"Congratulate me, my child!" he answered, sadly, for of all persons, he was the least to be congratulated, he thought. "And for what?"

"Upon the passage of your bill!"

"Are you dreaming?" he asked, excitedly, the swift color tinging his cheeks. "I stayed till it was read, and it seemed capable only of defeat."

"But I am not dreaming. The session did not close till midnight, and your bill was the last acted on, and it was passed. I begged father to let me bring you the news."

Professor Morse grasped his young friend warmly by the hand, and as well as joyful and conflicting emotions would permit him, thanked the bearer of the glad tidings.

The passage of his bill meant money. Money meant the construction of a telegraph line, and the construction of a telegraph line meant the realization of the one fond dream that had so long possessed him. No lover, who, with trembling ecstasy, receives his first kiss, was ever so thrilled with delight. No mother, who, in silence and awe, gazes for the first time on the face of her first-born, was ever so solemnly glad. In the rapid flight of his imagination, he saw the line constructed and the messages flashing back and forth, the stupendous triumph of the century.

"You shall be the first to send a message over my line," he said, graciously and gratefully tendering to the girl at his side this distinguished honor.

With faith in her gifted friend, "I will hold you to that promise," she answered. "Remember!"

"Remember," replied Mr. Morse, genially, and they

parted. Morse immediately repaired to Baltimore and began the construction of the line. His first idea was to sink the wires connecting Baltimore with Washington in underground leaden pipes. After repeated failures, he found he had sunk thirteen thousand dollars in a fruitless endeavor to lay the wires, so the plan was abandoned, and he placed them on poles. It is a significant fact that this plan of burying the wires is at the present hour again being agitated.

In the beautiful month of May, 1844, Morse stood by his instrument waiting to fulfill his promise to Miss Ellsworth. One magnet and recording instrument lay in silent readiness in the Supreme Court chamber in the Capitol at Washington. A single wire threaded its way through the city, crept on through marsh and solitude, a weird, unnatural thing, found its way at length to Baltimore, and in the Mount Clare Depot touched the recording instrument and sister magnet. The supreme moment in the life of Morse had now come. Miss Ellsworth with childlike faith had answered his call, and now stood before the instrument, Morse by her side.

"What hath God wrought!" the machine responded to the touch, and the words were penciled forty miles away! In the archives of the Historical Society at Hartford, Conn., is to be seen the original of this message so grand in its simplicity, and to which Morse referred at the unveiling of his statue in Central Park, New York, twenty-seven years afterward. He said in referring this invention back to the Supreme Author and Inventor, Miss Ellsworth had given him a refuge where he might withdraw when the waves of adulation and honor swept dangerously high.

May 27th, 1844, the news was flashed into Washington over this same wire that James K. Polk had been nominated

for the Presidency by the Baltimore Democratic Convention. An evening paper had the temerity to publish this dispatch, the first printed message, and it was everywhere received with incredulity. When the morning train from Baltimore brought the confirmation of the telegram, she put the final seal on the triumph and fortune of Morse. Poverty, so long his grim companion, deserted him, and in her stead he found wealth smiling at his side, Fame, who generally places her laurels only upon the brows of the dead, for once relaxed her iron rules and gave him her greenest wreaths.

Everywhere the telegraph began to send out her miles of wires. No longer weird and uncanny, a group of wires soon came to be recognized as the signal of an advanced civilization. Europe stretched forth her willing hands to take the Morse instrument into her domains, and ten of her governments, at the instigation of Napoleon, held a convention in Paris and tendered to Morse the sum of four hundred thousand francs. What years of anxiety and toil he might have been spared had half that sum been presented with his *brêvet d'invention.* The Sultan of Turkey presented him with a decoration set in diamonds.

In the full meridian of life, crowned with wealth and honor, his ambitious dreams happily fulfilled, Morse could now calmly enjoy that rest which is so sweet after toil. He was remarried in 1848, and his home in New York he began to adorn with all the beauties that a refined and æsthetic taste could suggest. Here the genial society of his wife and the mad romps of his interesting family of children gave a new impetus to those fountains of affection in his heart which had been well-nigh absorbed by the intense strain of thought of former years. The wealthiest and most cultivated were glad

to be welcomed at his fireside, where his refined and dignified bearing, his inexhaustible fund of information, and his genial hospitality placed them in an atmosphere of exquisite enjoyment.

In the summer he retired with his family from the heat of the metropolis to his country home on the Hudson, a few miles south of Poughkeepsie, one of those wildly romantic spots where his artist's eye could revel in the contemplation of those wonderful and sublime pictures with which Nature has here adorned her canvas. This had been the only unfulfilled ambition of his life, the ambition of being an artist. We can imagine him standing some summer morning in this vine-wreathed Italian villa where the roses clambered and the honeysuckle hung its golden bells, with head uncovered in wrapt contemplation of the sunlight touching into gold the languid river at his feet, falling in broken shafts down some rocky chasm, or glinting against the huge trees about him. At such a moment he must be excused if for a brief instant he is compelled to cast a backward, passionate glance, "wild with all regret," to what he might have done or been in art had he not sacrificed beauty on the altars of science.

Morse had a commanding appearance that immediately attracted attention. His face bore the unmistakable stamp of genius, of patience, self-discipline, capacity for endurance, indomitable will, and a certain mysterious indication of reserved power.

In Central Park stands a colossal statue of Morse done in bronze, the work of B. M. Pickett. It was unveiled June 10th, 1871, in the midst of an assembly of telegraphers that had come from every part of the United States to do homage to the great inventor. At the reception given at the Academy

of Music in the evening enthusiasm reached its height. All the wires in America were connected with the telegraphic instrument on the stage. Amid intense silence Miss Caldwell sent this message to every telegraph station on the continent, "Greeting and thanks to the telegraph fraternity throughout the world. 'Glory to God in the highest, on earth peace, good-will to men.'" Professor Morse, now over eighty years of age, his long and flowing hair and beard of snowy whiteness giving a look of statuesque repose and grandeur to his face, now placed his hands upon the keys and appended his signature, "S. F. B. Morse." Enthusiastic applause shook the house. Responsive greetings came crowding in from all parts of the world, from Canada and Cuba, from England and Japan. In a few impressive remarks Morse closed the evening.

When spring again came round and shy, capricious April was playing her wild pranks, Professor Morse "turned away and sought his chamber to lie down and die." Unlike most men to whose genius the world is glad to pay its homage, the foul exhalations of infidelity had never poisoned his mind. The faith bequeathed him by his Puritan forefathers and instilled by a mother's fond prayers, had like a guiding star followed him through youth and old age, sustained and admonished him through poverty and wealth, had thrown its silvery radiance upon the poor painter and struggling inventor, and now shone with increased splendor upon the illustrious and dying hero. Death came to him, not like a pale spectre of the night beckoning him away, but like a gentle mother that leads her tired child to rest.

"So melts a summer cloud away,
So dies a wave along the shore."

On the 2d of April, 1872, his immortal spirit took its everlasting flight to that realm where the electric current of happiness forever plays, its nether pole centering in the Eternal Magnet, God Himself.

## THE BELL TELEPHONE.

ALEXANDER GRAHAM BELL, the inventor of the speaking telephone and phonophone, was born March 3d, 1847, in the city of Edinburgh, Scotland, and received a liberal education, completing the course of instruction in the high school, and afterward in the university of his native city. Of his early life we know nothing beyond the fact that he belonged to a family already distinguished in the fields of science and literature, his father, Alexander Melville Bell, and his grandfather, Alexander Bell, having been distinguished for their researches and experiments in acoustic science. After completing his collegiate education in his native city he went to Wurzburg, Germany, receiving from the University there the degree of Ph. D.

In 1872 the family moved to Canada, where his father, Mr. Alexander Melville Bell, became an instructor of deaf mutes and a professor in Queen's College, Kingston. Mr. Graham Bell came to Boston and introduced his father's system of instructing deaf mutes and also became Professor of Vocal Philosophy in the Boston University, still continuing his experiments in acoustic science, which experiments led eventually to his wonderful invention of the telephone.

Mr. Bell was the first to invent a method of, and apparatus for, transmitting speech telegraphically by causing electrical

undulations similar in form to the vibrations of the air accompanying speech, and all so-called telephones which preceded Bell's worked by interruptions of the electrical current, and not only were not intended to transmit speech telegraphically, but could not possibly transmit, for the very good reason that interrupted or discontinuous electrical currents cannot copy the forms of the vibrations of the air accompanying speech, because such vibrations are continuous. All telephones previous to Bell's were intended for signaling by the Morse system, and operated by causing a receiving instrument to give out a musical tone of definite pitch; a long tone, or a long interval between two tones, and a short tone or a short interval between two tones, corresponding relatively to the dash and dot of the Morse alphabet, in Mr. Bell's invention the sound which is made or uttered at the transmitting station being faithfully reproduced by the receiving instrument. Up to the time of Mr. Bell's invention the transmission of speech could only take place by means of acoustic tubes or of the string-telephones. Bell's telephone reproduced articulate words. (The Edison telephone is based upon the action of undulatory currents.)

Mr. Bell's researches in electric telephoning began with the artificial production of musical sounds, suggested by the work in which he was engaged in Boston, viz., teaching the deaf and dumb to speak. Deaf mutes are dumb merely because they are deaf, as Mr. Bell has demonstrated by two thousand of his own pupils, that, when the deaf and dumb know how to control the action of the vocal organs they can articulate with comparative facility.

"My attention," says Mr. Bell, "was directed to the mechanism of speech by my father, Alexander Melville Bell.

Together we carried on a number of experiments, seeking to discover the correct mechanism of English and foreign elements of speech, and I remember especially an investigation in which we were engaged concerning the musical relation of vowel sounds. When vowel sounds are whispered each vowel seems to possess a particular pitch of its own, and by whispering certain vowels in succession, a musical scale can be distinctly perceived. Our aim was to determine the musical pitch of each vowel, but unexpected difficulties made their appearance, for many of the vowels seem to possess a double pitch, one due probably to the resonance of the air in the mouth, and the other to the resonance of the air contained in the cavity behind the tongue, comprehending the pharynx and larynx. After many experiments I thought I had hit upon an expedient for determining the pitch, but mature consideration revealed the fact that this deficiency lay in the nature of the electrical current employed and was finally obviated by the invention of the undulatory current.

"I had been invited by the Boston Board of Education to conduct a series of experiments with the system in the Boston School for Deaf and Dumb. One of the telephones was placed in my lecture-room in the Boston University, and the other in the basement of an adjoining building. One of my students repaired to the distant telephone to observe the effect of articulate speech, while I uttered the sentence, 'Do you understand what I say?' into the telephone placed in the lecture-room. To my delight the answer was returned through the instrument, its articulate sounds proceeded from the steel spring attached to the machine, and I heard the sentence, 'Yes, I understand you perfectly.' It is a mistake to suppose that the articulation was by any means perfect,

and expectancy, no doubt, had a great deal to do with my recognition of the sentence, still the articulation was there, and I recognized the fact that the indistinctness was entirely due to the imperfection of the instrument."

Mr. Bell patented the telephone May 8th, 1876, and in its present form, June 25th, 1876. It was exhibited at the Centennial, in Philadelphia, whence the story of this wonderful invention spread throughout the world.

That Mr. Bell has had his seasons of doubts and discouragements, we have no doubt; that he has also had his times of persecution, the history of the famous telephone lawsuits testify; that he has emerged victorious with wealth, fame, and honor to keep his place among the world's great inventors cannot be denied.

It is a strange fact that important discoveries are often made almost simultaneously by different persons in different parts of the world; and the idea of multiple telegraphy seems to have occurred independently to no less than four different persons in America and Europe. Even to the details of the arrangements upon circuit: by Mr. Cromwell Varley, of London; Mr. Elisha Gray, of Chicago; Mr. Paul La Cour, of Copenhagen, and Mr. Thomas Edison, of Newark, N. J. Mr. Elisha Gray, of Chicago, deposited his specifications and drawings for a speaking telephone in the U. S. Patent Office in the form of a *caveat* on the 14th of February, 1876, a few hours later than Mr. Bell's application for a patent.

The first successful experiment over a telephone wire was between Boston and Cambridge, on November 10th, 1876. Before April, 1877, a line was built from Boston to Somerville, forty-four miles, and is described in the *Boston Advertiser* of April 5th, 1877: "The first telephone line ever es-

tablished has just been constructed between the office of Mr. Charles Williams, electrician, of this city, and his home in Somerville."

America not only preceded Europe in the establishment of the telephone exchange, but in the application of new contrivances, many of which have been adopted by the telephone exchanges of Europe.

James Watt said: "That the maker of a great invention must pass through three stages in the estimation of the great mass of the public: first, it would be said 'it was impossible;' next, it would be said that 'he had not done it;' finally, it would be said that, 'it had long been known.'" It may be added that when an inventor has reached this last stage of attack he may be certain that both the reality and the value of his work have been assured.

When it was announced that the electrical transmission and reproduction of articulate speech had been accomplished, the novelty and utility of the invention elicited the wonder and admiration of the world. It first engaged the attention of the scientists, by whom it was unqualifiedly accepted as a novelty and a wonder. It was accepted at the outset as the unrivalled discovery of a new art. Having passed the crucial test of a scientific investigation, it rapidly acquired a commercial standing by reason of its great utility. It did not supplant other devices of a similar character, but took possession of a field theretofore unoccupied. It is an historical fact that the introduction of valuable and important inventions is productive of a host of rival claimants; and so the steady growth and assured success of the articulating telephone as a commercial venture had the usual effect of developing, reviving, and resurrecting all manner of inven-

tions and contrivances, both near and remote, upon which the shadow of a claim to priority could possibly be based. Stimulated by visions of glory and profit, all manner of incomplete, dormant, unsuccessful, and abandoned instruments and devices have been brought to light, polished, and made to resemble as much as possible the real article, in order that their projectors might obtain the profits.

It is a curious fact that no rival claims of priority to the invention of the electric-speaking telephone were made in any quarter until more than a year after the description of the experiments of Mr. Bell had been published by the journals of the entire world. The claims were first put forth in the interest of the Western Union and Gold Stock Telegraph Companies.

In the summer of 1875 Mr. Bell asked permission of the Western Union Telegraph Company to conduct experiments in the office of their electrician in New York. This was granted, but shortly after Mr. Bell began his experiments Mr. Orton, President of the Company, learned that a gentleman, who was personally obnoxious to him, was pecuniarily interested in Mr. Bell's inventions, and immediately directed that the permission to conduct his experiments should be withdrawn. After Mr. Bell had brought his invention before the public, and was endeavoring to perfect it by experimenting over actual telegraph wires, orders were given to exclude him from the Western Union wires. In spite of those orders experiments were conducted over them, but for a long time the results were looked upon as possessing little practical value. In 1877 the progress of Mr. Bell's inventions was deemed to have arrived at such a state of efficiency as to threaten to be a serious competitor to the telegraph. The

President of the Western Union Telegraph Company said to the electric expert of the Company, "I have been looking into the matter of the telephone somewhat, and regard it as a matter likely to be of considerable future importance. If this proves to be the case we should have the right to use it; therefore I wish you to make a thorough investigation of the whole subject and ascertain what are the fundmental principles of the invention and what inventions and patents it will be necessary for us to acquire the control of in order to be able to use the invention in connection with our business."

Afterward Mr. Prescott, one of the Vice-Presidents of the Company, visited Professor Dolbeare to ascertain the character and extent of his claims to priority of invention. This visit was made in August, 1877, and resulted in an agreement between the Gold & Stock Company and Professor Dolbeare, by which the Company acquired the ownership of and agreed to exploit his telephonic inventions. About the 1st of December, 1877, the Gold & Stock Company made an arrangement with the Harmonic Telegraph Company by which Mr. Gray's inventions in harmonic telegraphy were also acquired and united with those of the Gold & Stock Company, forming the basis of a new organization called the American Speaking Telephone Company. This company was to own all the patents and profits of the business, but the management was to remain with the Gold & Stock Company.

In the meantime suits were brought under Mr. Bell's patents against those who used the telephone in this company, and one of them, in the United States Circuit Court, at Boston, was vigorously pushed for trial. That suit was defended by the Gold & Stock Telegraph Company. The

answer set up a great variety of defenses, among others the European publications relating to Reis's invention, and it was alleged that Bell's telephone as described in his patent of March 7th, 1876, was not capable of talking. The Bell Telephone Company caused to be constructed twelve pairs of telephones, all of which did talk with practical success, and all of which exactly conformed to the description in the patent. They were constructed by different persons in different shops, and were tried by many different persons.

In his charge to the jury in this suit the judge said: "There is considerable evidence that Bell's experiments were not entirely satisfactory, but this is now immaterial, for it is proved that the instrument will do the work whether the inventor knew it or not, and in the mode pointed out in the specification."

Regarding the novelty of Mr. Bell's invention, the Bell Company brought out many acknowledgments by experts that they had never heard articulate speech transmitted over a telegraph wire by means of electricity except through Bell's invention. After a very vigorous defense had been made by the Gold & Stock Company, and testimony at great length and expense had been taken, Mr. Gifford, one of the counsel for the Gold & Stock Company, became convinced that Mr. Bell was the first inventor of the telephone and that his patent had been infringed, and advised the Company to that effect, and suggested that the best policy for them was to make some settlement with the Bell Company. After many negotiations between the interested parties, the Gold & Stock Company transferred to the Bell Company their exchanges for costs, and thus ended the first attack on Mr. Bell's invention of the electrical speaking telephone.

In July, 1876, Mr. Edison learned of Bell's Centennial exhibition of the articulating telephone, and in the same month the first evidence is disclosed of a distinct effort on his part to construct an instrument designed for the transmission of articulate speech.

Professor Dolbeare began his experiments in August, 1876.

In 1861, and subsequently, Philip Reis, in Germany, made an electrical instrument to be operated by the voice. It was known as an instrument which could transmit sound, but not speech.

In 1869 Dr. Van der Weyde described an apparatus invented by himself which could transmit pitch and rhythm, consequently, melody, and nothing more.

Mr. McDonagh, of Chicago, invented a machine that could transmit musical sounds, and through which tunes could be distinguished, but not words.

Of the various claimants to the invention of the telephone, none has presented a more remarkable history than Mr. Daniel Drawbaugh, of Eberly's Mills, Pa. Mr. Drawbaugh is one of the universal geniuses capable of turning his hand to any mechanical work and doing it well; as an electrician he is self-taught. Between the years 1867 and 1876 he claims to have invented and actually used every form of telephone now known. He began with a transmitter made of a jelly-tumbler in which he used powered carbon to vary the resistance correspondingly to the motion of a diaphragm vibrated by the voice and a receiver constructed from a mustard-can, but in every other respect nearly identical with the first telephone made by Professor Bell. If Mr. Drawbaugh's claims are sustained there can be no question that his position as an

electrical discoverer will be wholly unrivalled. Within the last four years he has invented over thirty new telephones. At this date, over a thousand patents in the United States alone have been granted for various forms of telephones and devices "thereunto appertaining."

In 1819 Sir Charles Wheatstone invented a magic lyre, and in 1831 exhibited it at the Polytechnic Institute in London. He called it the "telephone," thus inventing the name. This was for the transmission of musical sounds only. It is related that shortly after Sir Charles had invented this device he invited a distinguished foreign musician, a noted performer on the violoncello, to dine with him. In order to surprise his guest he suspended a violoncello in his entrance hall, arranging in contact with it a concealed rod which communicated with a like instrument in another room. On the arrival of the visitor he was left alone in the hall, and naturally his attention was at once attracted by the strains of music apparently coming from no visible source, yet clearly being produced in the same apartment. Finally he traced them to the instrument on the wall, examined it critically, could find no reason for them, and then, as if struck with sudden terror, with a cry of dismay, the affrighted musician rushed out of the house. Nothing could convince him that the instrument was not bewitched, nor induce him to trust himself again to its proximity.

The idea of transmitting sounds by the voice through solid conductors is known to date back to 1667. At that date Dr. Robert Hook wrote: "It is not impossible to hear a whisper at a furlong's distance, it having already been done, and perhaps the nature of the thing need not make it more impossible, though that furlong should be ten times multiplied, and

though some authors have affirmed it impossible to hear through the thinnest plate of Muscovy glass; yet I know a way by which it is easy enough to hear one speak through a wall a yard thick. It has not yet been thoroughly examined what other ways there may be of quickening our hearing or of conveying sounds through other bodies than the air for that is not the only medium that I have, by the help of a distended wire, propagated the sound to very considerable distance in an instant, with as seemingly quick a motion as that of light, at least incomparably quicker than the air, and this not only in a straight line, but in one bended at many angles."

In 1880 there were three telephone exchanges in New York city—the Bell Telephone Company, the Law Telephone Company, the Gold & Stock Telegraph and Telephone Company. The two former use the Blake transmitter and the Bell receiver, the latter the Edison transmitter and the Phelps receiver. During the summer of 1880 the exchanges of the Gold & Stock Telegraph Company and the Bell Telephone Company were purchased by the Metropolitan Telegraph and Telephone Company, and incorporated under the one system and management, those of the Bell Company being adopted. The Metropolitan Telegraph and Telephone Company divided the city into eight districts, and in each established a central exchange. These central offices are located as follows: New, Murray, Spring, Pearl, Nassau, Walker, Twenty-first, and Twenty-second Streets. These exchanges are connected with each other by trunk lines and also with exchanges in Harlem, Brooklyn, Yonkers, Jersey City and other neighboring towns. There are in New Street central office ten young women at two operating tables, seven at the annunciator cases, and one boy to pass the slips.

The New York central office has thousands of subscribers and hundreds of lines running to different points, and averages twenty thousand connections each day, each connection being made upon both trunk and local lines on an average in thirty seconds.

The Metropolitan Telegraph and Telephone Company, the New York and Law Telephone Company, and other smaller telephone corporations are mostly submerged into the Bell Telephone Company.

Number of telephones existing in the United States, March 1st, 1880, 138
" " " " 1884, 890
Total increase for the four years, 752 or 544 per cent.

Earnings for rentals of telephones for the year ending February 28th, 1881, $535,754 81
" " " " 1884, 1,695,678 58
Total increase for the four years, $1,159,923.77.

From 1884 to 1893 the increase in the number of telephones was so great that only a vague conception of the enormous rentals may be approximated.

At Newport Torpedo Station conversation was carried on over five miles of submerged cable and an equal length of land wire.

Experiments were made between Dover and Calais over a cable line twenty-one and three-quarter miles long. Several ladies and gentlemen were present and conversed with second parties in France for two hours. The cable was a four wire cable, and the conversation was carried on over one wire, while the other three were working direct with London, Paris, Calais, and Lille; and the signals made by the three wires could be distinctly heard through the telephone, and, at times, when but one of the wires was working the Morse signals could be deciphered, and a message that was going through from Glasgow to Paris read.

Whenever a telephone line approximates a telegraph line the Morse signals can be plainly heard in the telephone receiver, and where a Wheatstone, automatic instrument is at work, or, as in the case of electric-lighting wires, where a dynamo is supplying the current, the roars and whirrs heard in the telephone completely obliterate all other sounds.

Telephoning over sub-marine cables is impracticable for long distances owing to the effects of induction and retardation.

Tests on artificial lines, representing the Atlantic Ocean, show that probably the maximum distance over which speech can be distinguished does not exceed one hundred and fifty miles. Conversation has, however, been successfully maintained between Brussels, Belgium, and Dover, England, through sixty miles of cable and two hundred miles of air line.

In experimenting with sub-marine cable before a signal can be made the whole cable must be charged with electricity, and if there is not sufficient electricity sent in for this purpose no signal appears at the distant end.

It is difficult to assign any distance over which speech may not be telephonically transmitted. So long as the effects of induction and leakage cannot be neutralized, the possible distance of telephoning must depend on accidental conditions. Sometimes it is impossible to get speech over a line a few miles in length.

Cases have been found where a line, first passing over water and then over earth, or extending over rock and then ground, would refuse to transmit until taken down and carried around the shore of the water-course or away from the vary-

ing soil. Speech has been transmitted between Chicago and New York and New York and Philadelphia over the regular telegraph wires. Telephoning without wires is a possibility, and promises extraordinary results.

When an electric light system uses the earth it is stoppage to all telephonic communication in the neighborhood. The whole telephonic communication of Manchester, England, was one day broken down from this cause, and in London the effect was at one time so strong as not only to destroy telephonic communication, but to ring the bells.

Shortly after the telephone came into use Mr. Smith connected a piece of silenium with the instrument and heard a ray of light fall upon the bar.

Professor Bell, in conjunction with Mr. Sumner Tainter, was the first to perfect an instrument to transmit speech by a ray of light, and to realize what Mr. Bell called the extraordinary sensation of hearing a ray of sunlight laugh, cough, sing, and talk with articulate sounds. This apparatus is called the Phonophone.

What improvements the future will bring to the speaking telephone can hardly be conjectured. In the way of loud talking much has already been accomplished of which the public knows nothing. Ordinary receiving telephones can be made to talk loud enough to easily be heard throughout a good sized room at a distance of thirty or forty feet from the instrument. A good instrument should easily transmit speech uttered twenty feet away from it. The ordinary commercial telephones do not do this, because they are very indifferent types. The great need is a way of neutralizing the effects of induction, leakage, and retardation, and with accidental conditions incident to all lines. When that is accomplished

there should be no more difficulty in talking between New York and San Francisco than from one room to another in the same building.

## The Telephone Abroad.

*The Westminster Review* says: "Of all novel inventions connected with transmitting electric telegraph symbols, the telephone devised by Mr. Alexander Graham Bell, of Boston, has excited the most wide-spread interest and wonder. Wherever Mr. Bell has appeared before an audience to give an account of his invention crowds have assembled to hear him. Nor is this astonishing, for the telephone professes, not only to convey intelligible sounds, but to transmit in *fac simile* the tone of the human voice so that a voice shall as certainly be recognized when heard at a distance of a few hundreds of miles as if its owner were speaking in a room at our side.

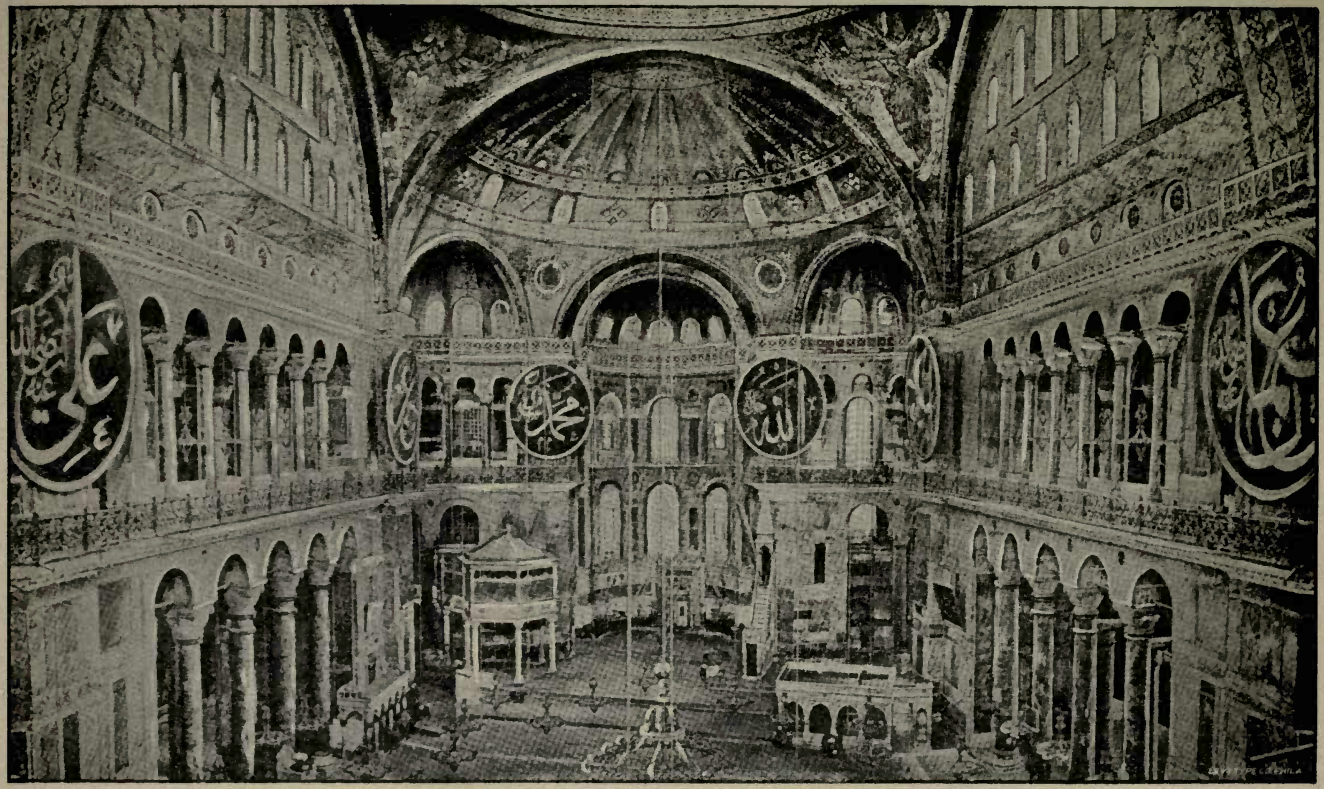
"Scientific men have had their curiosity and wonder excited even more than the unscientific public since a scientific man appreciates the enormous difficulties to be overcome before such an invention can be realized. The effects are so marvelous, the existing, so inadequate to produce them; for a telephone message must differ as widely from an ordinary telegraph message as a highly finished oil painting differs from a page of print. In the one we have only white and black, black symbols on a white ground, the symbols being limited in number and recurring again and again with no more difference of order. The painting, on the other hand, discloses every variety of order and arrangement, no sharp lines of discontinuity offend the eye, on the contrary, the tints shade off gradually and softly into each other, present-

ing tone and depth in endless variety. The page of print is unintelligible without the aid of a key; the painting tells its story to any one who has eyes to see."

In 1880 there were two telephone companies in Paris, one using the Gower telephone and the other the Edison; a third company introduced the Blake transmitter, but was soon consolidated with the Gower Company, who were the first to introduce the telephone annunciator in that city.

The Central Telephone Office in Paris is one of the most complete, and practically perfect telephone exchanges in the world. The central office is situated in the very heart of the capital. The subscribers are connected with the office in the basement. The wires which arrive at the central office are inclosed in cables; these telephone cables are placed in the city sewers under the technical service of the administration of the state telegraphs. These cables are suspended by hooks fastened into the stones of the sewer vaults. Each of the wires contained in the cable is formed of a copper conductor, consisting of three strands covered with a layer of gutta-percha, and afterward by an envelope of colored cotton. Each cable contains fourteen conductors thus composed. They are formed into a rope, covered first by a strong linen tape and then by a sheath of lead. The wires are of various colors to the number of seven, each pair of wires of the same color serving for a single subscriber. These colors are white, blue, yellow, maroon, black, red, and green. Each cable is numbered throughout, and it is thus easy to find the wire when it is necessary as well as to change connection.

The telephone company generally lay a main cable only after grouping seven subscribers in the same neighbor-



INTERIOR MOSQUE ST. SOPHIA.

hood, in the meantime subscribers are served by temporary cables of two conductors.

The branches to houses are made by means of small special cables of two wires bound to the principal cables by means of a ligature upon a lead conductor. Every house in Paris has what is known as its particular sewer—this is simply an archway made under the sidewalk, and commences at the side of the house itself, and stops at the main sewer. All sewers, except the main collectors, are under the sidewalk, near the curb. The collectors are under the roadway, but they are, in fact, small rivers into which the main sewers empty. To set the little cable for the particular sewer to the outside they simply make a hole close to the side of the particular sewer through the sidewalk and into this sewer, in the hole they insert a perpendicular gas-pipe, which projects six or seven feet out of the hole, and through this gas-pipe they run the little cable.

Besides the central office, subscribers are provided with offices which are connected directly together by means of auxiliary cables.

The Ader telephone is most employed, but the subscriber can choose his apparatus from any of the following: Ader, Gower, Blake, and Edison.

The double wire system is used exclusively.

The organization of the telephone service in the provinces is far from being as perfect as in Paris, nevertheless, they work regularly in all the large cities of France.

One of the most popular attractions at the Paris Electrical Exhibition, of 1881, was the demonstration of the marvelous powers of the Bell telephone, by its transmission of the singing on the stage and the music in the orchestra of the

Grand Opera to a suite of four rooms reserved for the purpose in one of the galleries of the Palais de'Industrie. This demonstration was given usually between eight and eleven o'clock, and an enormous number of people crowded the entrance to the building before the doors were open to the evening visitors. As soon as they could gain access to the galleries adjoining the telephone rooms they patiently awaited their turn for admission and the privilege of listening for a short time to whatever might be going on at the opera—solo, chorus, instrumental music, or, possibly all three, until the allotted time had expired and they had to give way to others. In this way eighty telephones were constantly at work at the same time, the communication was shifted at short intervals to another set of eighty instruments in two other rooms.

The transmitters were microphones of the Ader system, placed in front of the opera stage close to the footlights and behind them. Special arrangements were made to enable the one circuit from the transmitters, placed at the opera, to the receivers, placed at the concert-room to do the work properly.

A new acoustic effect was discovered by Mr. Ader, and applied for the first time in telephonic transmission at the electrical exhibition.

Every one who was fortunate enough to hear the telephones at the Palais de'Industrie has remarked that in listening with both ears at the two telephones the sound took a special character of relief and localization which a single receiver could not produce.

Another interesting experiment was performed recently between the Hippodrome and the office in the International

Telephone Company. The orchestra of the Hippodrome, which plays during the day and evening, was heard distinctly by invited guests assembled at the Place Vendome. There were ninety-six telephone receivers, and each auditor having two of them, forty-eight persons were enabled to hear at the same time. The clearness with which the music was heard was perfect, and all of the auditors were perfectly satisfied with the results.

The Swiss telephone methods are patterned largely after American methods. The wires are run overhead and are run from the tops of the buildings, the central offices having wire cupolas upon the tops of the buildings, the telephone wires used are of galvanized steel, and are never stretched beyond a strain of one hundred and twenty-five pounds, the sag being purposely made so great on account of the severe climate of this Alpine country. The telephone transmitters adopted by the Swiss are of various types, each having, they say, its merits and demerits.

## THE CHURCH.

THE vast agglomeration of thought, energy, organization, and spiritual power known to us, broadly, as the "Church Universal," and holding within its sphere of influence men of every conceivable shade of religious opinion, affecting the body politic of all Christian nations, and exerting no mean power in our own commonwealth—sprang from a lowly origin. The first Christian Church was formed by a secession from a Jewish synagogue. Afterward some synagogues were transformed into churches—or congregations—the ruling power being vested in Presbyters, who ultimately added to their office that of teacher, although they by no means held a monopoly of instruction, messengers from other churches, or specially gifted brethren, being welcomed as teachers by the congregation they visited. In these primitive days church edifices were unknown. Persecuted and despised, the followers of the new faith were driven to meet in obscure places, in the poorest streets of a city, in the woods, or, as in Rome, in the Catacombs. It was not till the third century that Alexander Severus gave a piece of ground to the Christian community to build their first church in Rome. As the number of converts and congregations increased, the simplicity of these early organizations gave place to more systematic govern-

MOSQUE OF ST. SOPHIA.

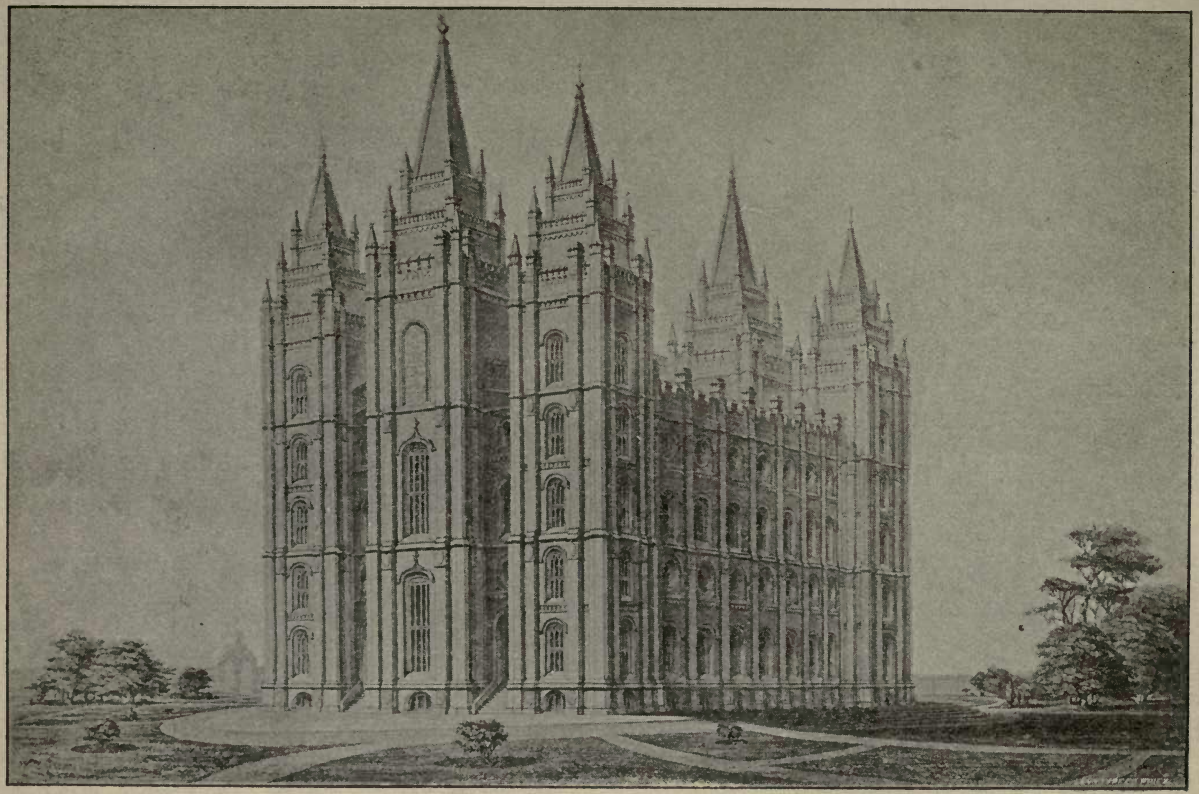
ment and more elaborate ritual of worship, and hence the priestly caste was developed from the primitive Apostolic ministry. The congregations fell into four divisions, and were seated in the churches in accordance. At the entrance of the building, between the porch and the interior, was an open space containing a pool of water—often a fountain—in which the worshipers laved face and hands before entering, as a symbol of the purity indispensable in approaching the Divine Presence. In this space, which formed a cloister or colonnade, the uninitiated or inquirers were permitted only to stand and look on. Within the church itself the outermost seats were allotted to the catechumens—those under instruction in the faith—the next were occupied by penitents—believers, but not yet in full communion—while nearest the altar, and the speaker of the day, sat those who had passed all these stages and become communicants. It was the invariable practice for the women to sit together on the right side of the building. As the congregations and buildings became larger the inconvenience of the orator standing as had been usual in a doorway or on the low steps near the altar, and so being ineffectually heard, led to the introduction of pulpits. With the growth of the priestly idea of the ministry a change in the manner of preaching gradually took place, till in the Middle Ages purely spiritual instruction was to a great extent superseded by teaching, having sole reference to the rites and ordinances of the church. The three orders of the ministry, bishops, priests, and deacons, remained unbroken, their work respectively being to govern, teach, and dispense charity; the latter duty being extensively shared as the centuries passed by numerous fraternities and sisterhoods.

During the incursion of the barbarians into Europe in the

fourth century the majority of the basilicas and smaller churches were ruthlessly destroyed, and from the sixth to the eighth century comparatively few were restored. Of those that were rebuilt, the grandest was that of S. Sophia, restored by Constantine; that even to the present day furnishes the finest ideal plans to the builders of churches. Foremost among monarchs of the earlier period who gave practical encouragement to church building was the Emperor Charlemagne. During the tenth century a prophecy that the end of the world was imminent gained such firm hold on the popular mind that an entire cessation of activity in this regard was the result, but the world continued to exist; the neglected work was resumed in the following century, and in that period the number and magnificence of the churches erected was extraordinary.

The favorite site for a church was on a hill, a predilection to be accounted for, probably not only by the universal tendency of mankind to worship in whatever way on the highest spot within reach, but also by the frequent necessity in those stormy Middle Ages of turning the church into a fortress.

The period of multiplication of great religious edifices, and of enormous expenditure on their construction, was marked by many abuses. To secure means for this lavish display, and the support of the augmented staff of the clergy, the people were heavily burdened, and methods of extortion devised that were very far from being in accordance with the code of morals enjoined on the primitive Church by its great Head. Greed, injustice, and corruption ran riot till, about the end of the fifteenth century, an under-current of opinion began to make its way among thoughtful men that the time was coming for reform. An opinion at first kept much out



MORMON TEMPLE, SALT LAKE CITY.

of sight, but as general as in our day and country is the desire for tariff reform.

This sentiment grew steadily till, at the beginning of the sixteenth century, before the birth of Luther, it had permeated every grade of society, and the need of essential reform was fully recognized.

The scandalous lives of ecclesiastics, the arbitrary proceedings of successive popes, and the abuse of ecclesiastical power aroused intense antagonism, and not only among the laity, for many of the higher-minded clergy appeared as doctrinal reformers, and seeing that there was little prospect of the pope inaugurating a better state of things, commenced to take action independently by earnestly propagating their own ideas.

That these early reformers were not actuated by exclusive religious feeling is tolerably certain. In the sphere of political action the influence of the popes was comparatively insignificant, and national reform (as Luther himself said in 1520) being needed as much as that of the Church, political and religious thought became intermixed in the minds of most men of that day.

In the upheaval of the old institutions that culminated in the establishment of the principles of the Reformation, Germany led the way, followed by England; united Christendom resolved itself into a group of national and local churches, with the result of large improvement in the social, moral, and religious state of the people.

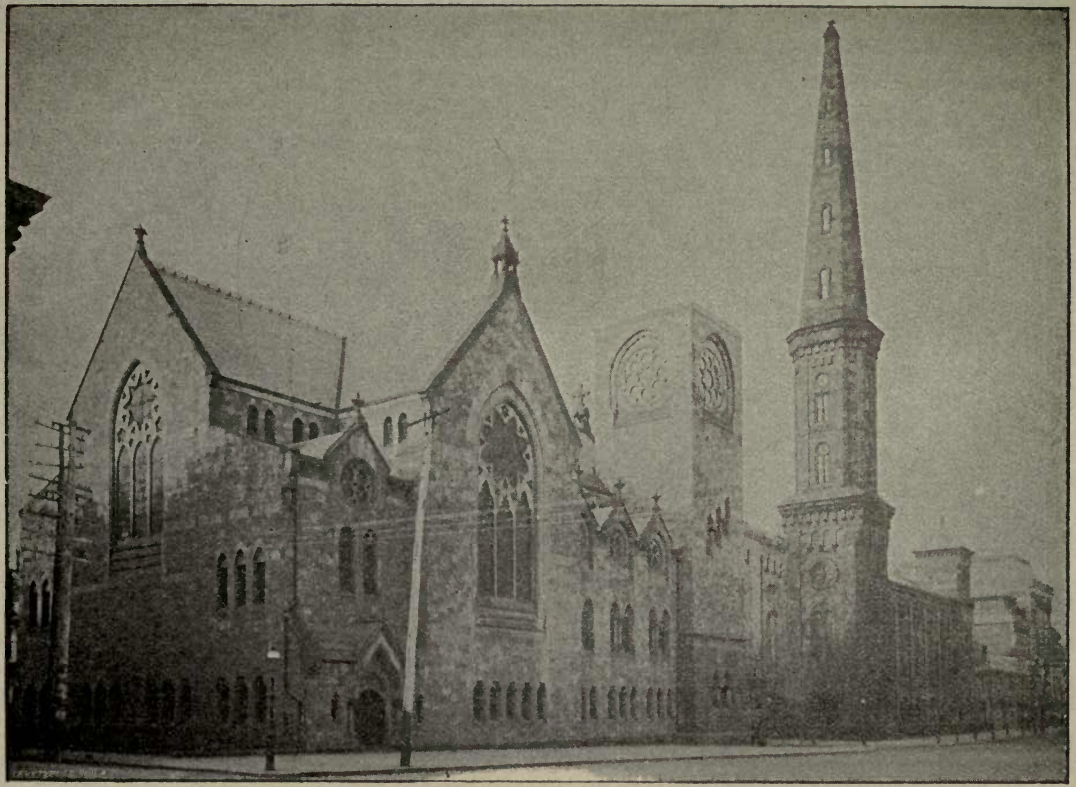
While agreed on most general principles, the various sections of the Reformers clashed considerably in opinion; the churches exhibited a litigant spirit, and divided into numerous sections, these disagreeing continually: a section bene-

fited by some particular reform being unable to see that it would not be desirable for another section, who were not in need of it; consequently, the two sections clashed just as in our day the tariff reformer of the South disagrees with the tariff reformer of the North, whose productions, manufactures, and wants are of a totally different character.

Eventually, the people of Christendom divided into two classes, which may be described as negative and affirmative. The negative, or Protestant party, rejecting tradition as untrustworthy, and insisting on Biblical teaching only, and the right of private judgment on matters of doctrine. The affirmative, or Roman Catholic party, adhering to the traditions of the Church, and absolutely denying the right of private judgment in interpretation of Scripture.

From the period of the Reformation onward the builders of churches in England and America have given less attention to the architectural aspect of their work and more to the needs of modern congregations. The seating capacity has been a primary object, and the interior comfort and acoustic properties have been more carefully studied. There is no reason to believe that any unnecessary care for economy has prompted the modern style of church edifices, inasmuch as in most of our great cities very costly sacred buildings are to be found, but it would seem probable that wealth is more freely bestowed on these structures because they are built by the people for the people, and are not paid for by the State.

One of the most perfectly modelled church-buildings in this country in point of acoustic properties is the Mormon Temple in Salt Lake City. Its peculiarity consists in the floor ascending and the roof descending from the altar to



A MODERN CHURCH.

the far end of the auditorium, so that the voice of a speaker being thrown forward between converging planes is carried perfectly to the most distant point of the building.

The one division desired to retain all the observances of the established ritual, the forms and methods of Church government, sanctioned by Rome; the other, or Protestant party, rejecting all of these which were unsupported by Scripture or the practice of the primitive Church.

## THE STAGE.

THE universal taste for the drama in its multiplied forms, whether tragedy, comedy, melodrama, burlesque, or the varieties of opera, is beyond dispute, and the *raison d'être* is not far to seek. The absorbing interest of a serious play, the gayety of comedy, or the hilarity of comic opera and burlesque are strong counter-irritants to the dullness and depressing influences of our prosaic every-day life. That the majority of any civilized nation should enjoy theatrical entertainments is no wonder. But the motive which prompts men to engage in a profession which is at once arduous, precarious as a source of income, and in which the highest honors are attainable only by a very limited minority, is less easily discovered.

It appears tolerably certain that a comparatively small number either of men or women select the profession (or have it selected for them), with the same definite purpose or contemplate adopting at as early an age as they usually determine on becoming clergymen, lawyers, doctors, artists, or going into trade. With the exception of a few theatrical families, whose children are attracted by the parents' successful career, and are frequently trained to the stage as a matter of convenience almost from babyhood, the large majority of actors and actresses seem to drift into dramatic life almost aimlessly and under the pressure of extraneous circumstances.

THE AUDITORIUM, CHICAGO, ILL.

The life is too exacting, the prospect of accumulation of wealth too slight to induce persons of a practical turn of mind to consider acting a sure road to money-making, and it is the unpractical mind of youth therefore that most often selects the stage as its sphere. The few who become actors later in life are almost invariably amateurs who have tasted the sweets of applause in their own circle and in whom the appetite for display grows till only the plaudits of the public can satisfy it.

Whether even public approbation is an entirely satisfying mental diet is open to question, for it has often to be taken with the bitter herbs of envy, jealousy, and hard work. In great part the hopes and imagination of aspirants to dramatic fame are quickly disappointed, insomuch that having been "behind the scenes" has become a synonym for having discovered a deception. In a very short time the neophyte becomes accustomed to the tinsel and false show, disenchantment follows, and the theatre is no longer an Elysium but a place of business where every one has to work as hard as any other mortal in the world outside.

While there may be many secondary motives at work in a young mind to bias it in the determination to act in public—a romantic tendency that frets against the commonplace of daily life, love of excitement, restlessness of temperament—the general consensus of opinion among men of long experience in the management of theatres and the training of stage pupils declares personal vanity to be the primary and overruling motive, whether the would-be actor be cognizant of it or no. With the finer order of minds, true love of their art, as seen in its best development, springs up and confirms them in their affection for stage life. Others, when the

novelty has worn off, are content to look on their profession chiefly as a means of bread-winning, and to these it is rarely a life of entire satisfaction.

The most painstaking research has failed in discovering any data whereby the exact time of the birth of the drama may be fixed, but its life doubtless owes its origin to the universal tendency of human thought and feeling to represent in actual perceptible form its ideas concerning either invisible Deity or the moral and emotional aspects of human life. Dramatic art, in the earliest ages wherein we know it to have existed, was invariably founded on the rites and ceremonies of some religious cult. Having once been introduced, the dramatic element in the religion of Greece steadily increased, and from the first was intimately connected with the State worship of Bacchus, or Dionysus (the new name adopted by the Greeks for Helios, the sun god, the idea of the bright cheerful Bacchus being associated with Helios, the dispenser of light and joy, naturally merging into the worship of both as one divinity).

In the worship of Dionysus, at Eleusis and Delphi, the deity was personated by a handsome youth in a theatrical performance representing his betrothal to the daughter of the King Archon.

The earliest form in which the drama developed itself was tragedy, in which the serious choral poetry of Dorian worship was amalgamated with the mimetic dances and the songs of the worship of Bacchus. About the thirty-eighth Olympiad, Arion, the Methymnæan, is supposed to have introduced the innovation of a standing chorus and single characters speaking in verse. In the sixth century B. C., Thespis, an actor, whose native town was especially given to the Dionysian

worship, invented the art of "making up" the face with colors, and also a linen mask for the convenience of an actor playing two parts in one play.

The exact birthplace of Greek comedy is unknown, but this style of acting drama most probably arose in the country and was connected with the village harvest-festivals, the name springing from Κωμῳδια, song of Comos or revels. Comedy soon rose from mere mimetic show to true drama, attaining in time to songs, trained chorus, and systematic dances. The bulk of the audience having in this early period no knowledge of written plays, the subject of a dramatic representation was usually drawn either from a well-known public event or some court trial of interest, so that the spectators could readily comprehend the drift of the satire in which the early plays abounded, and appreciate the pantomimic display. The chorus also aided in keeping the motive of action clearly before them.

The first known Grecian theatre was a wooden structure, but this being destroyed by an accident, a great stone theatre (the Lenæon, or inclosure of Bacchus) was erected in its place, the construction occupying one hundred and twenty-nine years. It was built, as were those that succeeded it, on the slope of a hill, and consisted of a semicircle of steps hewn in the rock. Others, on soft ground, were formed of rows of stone steps built in rising tiers. The great theatre of Bacchus at Athens had a seating capacity of thirty thousand; all theatres built at that time were large enough to contain the entire population. Surrounding the seats there was a sheltered piazza, with balustrades and a fine portico, into which the audience could retire in case of a sudden storm, returning to the auditorium when it was over. For

protection from the sun, a huge awning of palm-leaf matting or sail-cloth, shaped somewhat like a parasol, was raised over the inclosure. The arrangement of this contrivance being difficult and dangerous, sailors were usually employed in its management. Besides giving shelter, this awning increased the facility of hearing the speakers, and its value in this regard has been exemplified in modern times by the use of one (copied from that of the theatre at Pompeii) at the Albert Hall, South Kensington, where it has proved successful in correcting the acoustic deficiencies of the building. The Albert Hall holds an audience of twenty-two thousand, and the softest sounds of speech or music are distinctly audible in every part.

The attendance of a whole city on an ancient dramatic performance may be accounted for partly by its religious character, partly because a play was seldom repeated, *never* more than once in a year. Plays were usually performed at the four Bacchic feasts in the sixth, seventh, eighth, and ninth months of the year, and occupied from ten hours to a day or two. Accessories to the better production of both tragedy and comedy came into use at the theatre in Athens; thunder and lightning were produced by the beating of copper sheets and the flashing of cleverly-arranged mirrors, and machinery was employed in bringing on the clouds from which the deities held conversations with the mortals on the stage.

From this period the drama steadily developed in various directions, but always, evolved as it was from pagan rites, in accordance with the religious bent of the public mind in the different countries of Europe, until the advent of Christianity, which slowly but surely undermined the power of the ancient

superstitions, and, turning heathen Saturnalia into a holy festival, heathen choruses to the hymns of a pure faith, gradually lifted the old imbruted world from the pit of corruption into which it had stumbled, and in purifying its civil and religious life, purified also its amusements.

Still, the drama in the early Christian centuries retained its religious motive, the manner of performance undergoing considerable modifications. The mediæval mysteries and miracle plays had for their motive Scriptural histories or passages from the lives of the saints, and were performed under the direction of the clergy. At first these plays were given in the churches, so that the stage accessories of the later Greek drama were necessarily dispensed with. The performers all appeared at once, each standing apart to speak his lines, except the devils, who usually were numerous and conspicuous, and for whom a space was kept clear from the spectators on the floor in front of the rude stage or platform, and from which they sprang up among the performers to tempt, maltreat, and otherwise worry the saint who was the hero of the piece. It is probable that this arrangement gave its name to the "pit" of the English theatre.

Stage illusions were unknown at this period, and the "unities" were not much considered by the ecclesiastics who were the authors of miracle plays and mysteries. They saw no incongruity in the appearance of the *dramatis personæ* in a body; whereas now each actor who leaves the stage returns apparently from the place where he is supposed to have been in the interval.

The use of the churches for plays was in time found objectionable, and performances were next given on a scaffold built against the church wall or in a field near by; later still,

about the beginning of the seventeenth century, in movable theatres taken from place to place.

The chief interest of all these dramas was tragic, and they are said to have been first acted in English about three centuries before the birth of Chaucer.

With the advance of education among the laity, and the consequent growth of purer sentiment, the grotesque and rude character of the miracle plays became distasteful to the more cultivated people of England, and as the poetic taste of the Elizabethan age developed secular plays became popular, and mysteries and their fellow-performances gradually died out. During the period when Shakespeare's plays were making their first impression, the playwrights discovered the value of scenery in aiding dramatic effect, and the desirability of excluding the audience from a knowledge of what was transpiring behind the curtain.

The first secular theatrical entertainments were given by strolling players, often in the open air, a wagon or rough scaffold forming the stage, and sometimes under shelter in a barn. Even after playhouses were built in the towns the strolling companies still lived, and were welcomed in rural places and at country fairs.

By the middle of the seventeenth century the secular drama, having made good its claim on the public approval, regular theatres were opened (presumably for the benefit of the upper ten of that day), to which admission could only be gained by invitation, which invitations, however, were not free, the fee exacted being equal or more to the prices at the public houses of entertainment. None of these theatres were by any means perfect in construction, although it betokened great advance on the Shakspearian era that they

were roofed, provided with comfortable benches, and possessed scenery. All were under the censorship of the Lord Chamberlain. The scenery was rough and imperfect, often dilapidated, and quite as often entirely unsuited either to the play or the house in which it was performed. But methods continually improved. For special representations new scenery was painted, the actors usually sharing the expense with the management (which was often vested as much in the company as in the ostensible manager).

In course of time the provincial towns became imbued with greater appreciation of the drama, and theatres were built in them, occupied at intervals by stock companies, which, if not quite up to the standard required by metropolitan audiences, were at least of immeasurably higher artistic calibre than the poor strollers whom they supplanted. From these stock companies to the traveling companies of the present day, who after a brilliant success in the great cities take the "successful" play "on the road," the transition was easy and made on an upward grade. The plays presented now having an infinitely greater range of subjects, are presented more attractively than was possible with our ancestors' lack of means to produce fine stage effects, and are acted by performers of higher mental cultivation.

The first theatre in America was built at Williamsburgh, Va., in 1752, and claims precedence as to the structure only, the first dramatic performances having been given in New York, in 1750, in an ordinary house fitted up for the purpose. After New York and Virginia had led the way, Annapolis and Boston followed, the first theatre in Boston being opened in 1792. As the population increased, and the wealth and higher intellectual culture of the nation grew even more

rapidly, the need of mental recreation was proportionally felt, and all cities having a population large enough to support one became each possessed of a theatre of its own.

These individual buildings, though rude in structure compared to those of our day, were remarkable for the originality of their arrangement and construction, in no case being modelled after the theatres of Europe, an idea which has been preserved and more amply developed in modern American theatres. Neither in the last or the present century do the exterior or interior features of play-houses present many points of identity with the structures of ancient times.

Of American theatres now existent the largest and most elegant are to be found in New York, Chicago, Denver, Boston, and Kansas City. The Warder Opera House in Kansas City is a very large building, and was opened with somewhat peculiar circumstances, under which the audience showed as much spirit of enterprise and enthusiasm as the management.

The first performance, given by Messrs. Booth and Barrett, took place while the edifice was still unfinished. For the first five nights the lowest priced seats cost two dollars and fifty cents. The interior scaffolding had not been removed, the roof had not been set on, and the audience were fain to muffle themselves in wraps and overcoats! Nevertheless the inauguration of Kansas City Opera House was a pronounced success.

Chicago, Cincinnati, Baltimore, Washington, St. Louis, Philadelphia, San Francisco, and Minneapolis all have theatres of superior structure and equipment, unsurpassed by any on the European continent.

The Tabor Opera House at Denver has some striking

characteristics beyond its size and beauty. Notwithstanding its ample seating capacity the means of egress are such as to secure safety, let the exit of the great audience be ever so hasty, and every detail of arrangement and fittings insures the maximum of comfort.

The first theatre in New York was established in 1750. In February of that year an editorial note in the *New York Gazette, revived in the Weekly Post-boy*, stated that a party of comedians had taken a room in one of the buildings, owned by the Hon. Rip Van Dam, Esq., deceased, on Nassau Street, and purposed to remain throughout the season, providing that the public gave them due encouragement. This building was on the east side of Nassau Street, between John Street and Maiden Lane, and its site is now occupied by stores and offices of comparatively old date. It was afterward used as a place of worship, and the congregation occupying it eventually pulled it down and built a church on the same site, which stood till 1810.

Contrary to European custom, the prices of admission made the pit (now termed the orchestra) the most expensive part of the house, the admission to it being one dollar and a quarter, and to the gallery, seventy-five cents. In 1751 boxes were added, the price being one dollar and a quarter, while the gallery remained at seventy-five cents, and the pit was lowered to twenty-five cents.

The population of the city was then small, and the majority were apparently not enthusiastic on the subject of dramatic art; for this, their only theatre, was closed in 1752, and not re-opened for a year. A Virginian company then came to New York and played a six months' season. A new theatre was built for them, said to have been larger, more commodi-

ous, and more elegantly fitted up than any in the country, but neither printed description nor drawings of it have been preserved. Shortly after this time an English manager came over and and built a theatre near what is now known as Coenties Slip, but it was only a temporary structure, and another was eventually built on the southwest corner of Beekman Street at a cost of one thousand six hundred and twenty-five dollars.

The population had now increased, but appreciation of the drama did not keep pace with its growth. The new theatre had from the outset to contend against much opposition, and in the stormy times of 1764 the building was attacked and almost totally destroyed by the mob. Theatrical enterprise was checked for awhile, but rallied again in 1767, when a theatre was built in John Street, which existed for thirty years, and a few years latter another was built in Greenwich Street. The drama had now established itself as an abiding inhabitant of the city, and from that time forward the growth of the theatrical element has moved on a parallel line with that of the wealth and æsthetic taste of the people.

The smaller towns in New York State are better provided with theatres than towns of the same size in any other part of America.

In the Southern States the architectural style of the theatres is more of the European character, and the interior arrangements based on the same plan. In New Orleans the orchestra (or pit) is the lowest priced part of the house, except, of course, the gallery. Baldwin's Theatre, San Francisco, is also quite European in appearance, having tiers of boxes all round the auditorium, but in this instance the price for the pit is higher.

Among the interesting theatres of the cities in the Pacific States, none is more so than the old California, now one of the finest in the United States, with every equipment for successful production of the elaborate modern drama, and enjoying the prestige of being the scene of the early triumphs of Edwin Booth and John McCullogh.

Of all modern theatres, the largest and most perfectly appointed, is the Auditorium in Chicago. The dimensions of its stage are one hundred and ten by seventy feet, with a height up to the bridge of ninety feet, and is, therefore, wider, but not quite so deep as that of the Metropolitan Opera House in New York. There is room upon it for an *ensemble* of over six hundred performers. The space in front of the footlights will afford room for an orchestra of ninety pieces, and there are three galleries. Five thousand opera chairs will accommodate the ordinary audience, but on special occasions the stage and foyer can be utilized for three thousand more, giving a total seating capacity of eight thousand. Twelve thousand, however, can be assembled within hearing of speakers on any great occasion, and a public orator, after making two speeches in the vast building at the great convention of 1888, pronounced its acoustic properties absolutely perfect. The Auditorium is consequently most perfectly adapted for musical purposes.

The stage, scenery, and curtain are of iron, and an organ built in is the finest in the world. The Chicago Conservatory of Music will appropriately make its home within the walls. The rehearsal room, which will be available for amateur performances and musical organizations, will seat from six to eight hundred people.

Not the least wonderful feature of this marvelous theatre

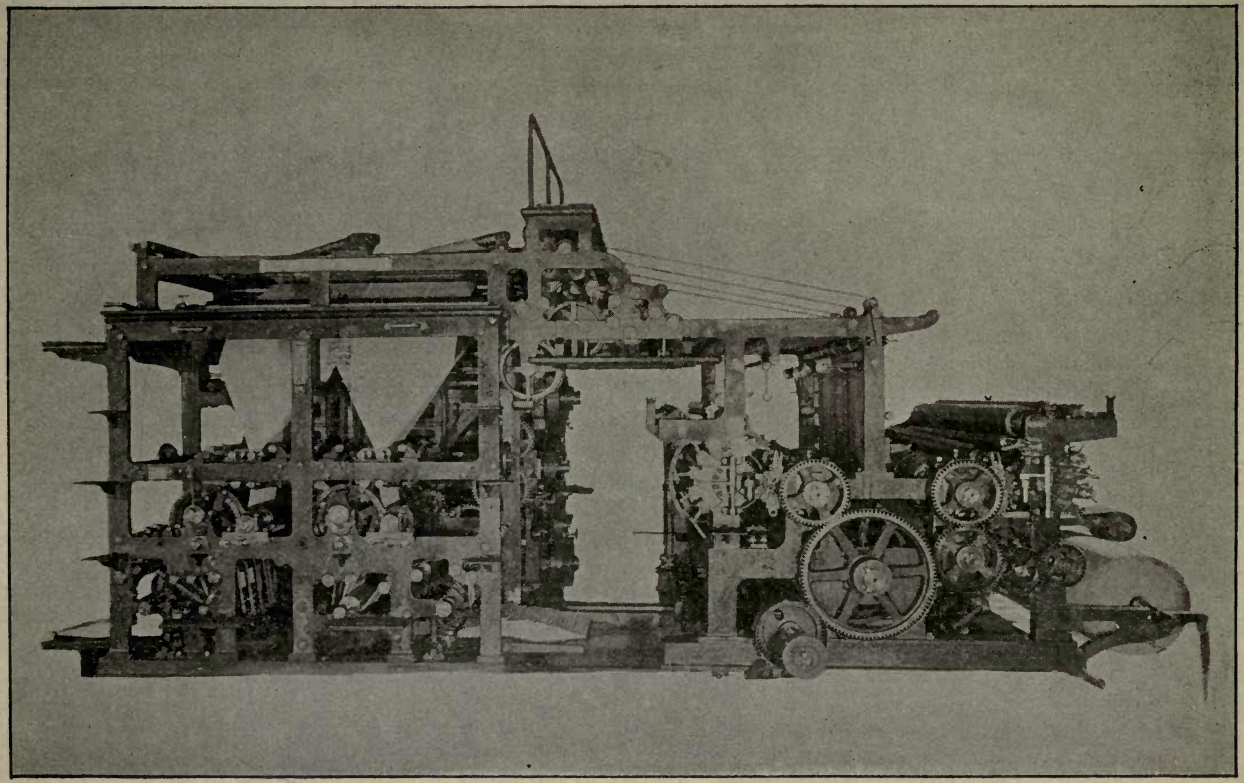
is the fact that it only forms part of a building, which for immensity and general beauty, is unrivalled by any other, either in the old or new world that is intended for the use of the people.

The Auditorium building covers nearly two acres of ground, fronting the lake, with frontage also on Wabash Avenue and Congress Street, the total being seven hundred and ten feet. Thirty-seven hundred tons of iron-work have been required for the work, the substructure is of dark granite, the pillars of polished granite, and the superstructure of lighter stone. There are ten stories, with a square tower forty by seventy-one feet, rising one hundred feet above the roof, and having seventeen stories. The platform of the tower will accommodate several hundred persons, and is reached by a special elevator. This forms a fine observatory, and the United States Signal Service have given notice of their desire for quarters on the top floor.

The Michigan Avenue front is a hotel, with foyers on the ground floor, about four hundred rooms almost all having southern or eastern exposure, and a magnificent dining-room on the tenth floor.

The building is absolutely fire-proof, seven hundred thousand dollars having been expended on fire-proof material alone. The Auditorium is supplied with three thousand Edison incandescent electric lights.

Apart from the hotel and auditorium, about one-third of the building will be devoted to art and education.



THE TRIUMPH OF PRINTING INGENUITY.

## THE NEWSPAPER.

THE average reader, as he takes up his daily journal, almost as a matter of habit, rarely pauses to consider—frequently does not even know—the enormous amount of mental, mechanical, and manual work, and the infinite ramifications of systematized labor that combine and have their final culmination in the sheet of printed matter that he so carelessly handles. In England the newspaper has been called the fourth estate of the realm; in America it is the second power in the State, the people themselves alone being above it. There are in the United States in this year, 1888, fourteen thousand two hundred newspapers; and the period of this extraordinary growth from the time when there was but one covers about one hundred years, its higher and more rapid development having taken place within about thirty years. Since its solid establishment in our country, the newspaper has not only grown with the people, but has been a prominent factor in their growth, following closely behind the pioneers as the population has spread westward; and doing so *literally* during the building of the Pacific railroad, when the *Frontier Index* had a peripatetic office which kept just ahead of the rails and locomotives.

In its earliest days the newspaper, strange to say, contained everything but news. The "powers that were"

strongly objected to the enlightenment of the people as to their doings, so that discussions on any subject except domestic policy filled its pages, and the little news inserted was chiefly foreign. It was not until the middle of the eighteenth century, when the breath of revolution was stirring the air, that the newspaper began to exert any power, and the cities that possessed a newspaper became centres of influence and political agitation, while journalists began their earliest attempts to mold public opinion. Soon the need was felt of better and more newspapers, and with this need came the demand for more adequate machinery of production. Inventions continually sprang into life, each succeeding printing-press became more complex, more rapid, and during the last decade the inventions in this line have been increasingly marvelous.

American journalism is now in its hundred and thirty-second year, the oldest living newspaper in the United States, the *New Hampshire Gazette*, having been issued in 1756. But the very first newspaper in the country was *Publick Occurrences*, issued in Boston, September 25th, 1690, by Richard Pearce for Richard Harris. The life of the infant journal was extremely brief. The good citizens of Boston took umbrage at the dangerous innovation of letting light in upon domestic and civic life, and pronounced such literature improper and pernicious to young minds, while the government took exception to having its proceedings discussed by outsiders, and summarily suppressed the enterprise before the second edition could be brought out. For a while news could only be circulated by means of letters, pamphlets, or circulars; but the spirit of journalism, once it became instinct with life, might be scotched but not killed; and in 1696 Ben-

jamin Fletcher, Lieutenant-Governor of New York, induced William Bradford, a printer of Philadelphia, to set up in New York and reprint the *London Gazette*, which gave an account of an engagement with the French a little while before the peace of Ryswick. This was the first victory of the free press of America over government.

The *Boston Newsletter* (which is commonly spoken of as the first American newspaper) was issued in 1704. The editor was Postmaster John Campbell; but succeeding editors usually followed some other calling, the majority keeping the taverns which represented the modern restaurant, probably selecting that trade as the likeliest to afford the daily bread that they saw no hope of getting out of journalism. Strangers in Boston inquiring for the newspaper were directed to the tavern, and for some now undiscoverable reason were, on asking for a copy, required to give references. The tavern was probably also regarded as a desirable location for the editor's office from its being a centre of gossip and newsgathering. In 1719, William Prooker, who superseded Campbell as Postmaster, started a paper of his own, the *Boston Gazette*, the second in the country, whereupon Campbell waxed indignant, and the first newspaper quarrel was put on record. It was exceedingly fierce and bitter, after the fashion set by the London newspapers nearly a century earlier. The day after the *Gazette* appeared, Postmaster Andrew Bradford issued the *American Weekly Mercury*, and two years after, in 1721, James and Benjamin Franklin sent out the first number of the *New England Courant*. Journalistic warfare now increased, but at length the Franklins were too strong for their adversaries, and Campbell sold his *Newsletter* to Bartholomew Green. Mean-

while popular culture had increased, and a higher order of newspapers was demanded; editors recognized the need of cultivating the peculiar talent required in newspaper writing, and journalism became a profession.

In 1727, Boston had four thriving papers, and Maryland one, the *Maryland Gazette.* In 1733, the *New York Weekly Journal* was established by John Peter Zengen, who was imprisoned for libel on the Government, and whose trial, and acquittal through the efforts of Andrew Hamilton, then leader of the Pennsylvania Bar, was the first great triumph of freedom of speech and of the American Press. About this time, South Carolina and Virginia each started a paper; both, however, were temporarily unsuccessful, but were eventually revived. In 1742, William Bradford, grandson of the printer, started the *Pennsylvania Journal,* which vigorously supported Colonial freedom. In 1775, Kentucky and Ohio each set up a newspaper in their respective capitals, which, after changing from name to name and hand to hand, still exist, and have a good circulation. During the revolutionary period several religious papers came out, but were soon dropped again. In 1748, only six greater cities supported newspapers, viz.: Boston, New York, Philadelphia, Annapolis, Williamsburg, and Charleston, S. C. In the same year Samuel Adams created the *Independent Advertiser,* in Boston, and ardently supported the revolutionary party. The sentiment of freedom was rapidly growing, and the *Boston Gazette* became the organ of the leaders who demanded Colonial freedom. It was not the ideal newspaper of to-day; consisting only of two pages, printed on a half-sheet of crown paper. Some seventeen or eighteen newspaper publications appeared now at various times, the *Virginia Gazette,*

in 1766, being the first to publish the Declaration of Independence.

In opposition to these revolutionary papers, the British had their own, the principal being *Rivington's Gazette*, N. Y., which had its office frequently mobbed by patriots, and the *Chronicle* in Boston, which shared the same polite attentions from the people. Major André was one of the chief contributors to *Rivington's*. From 1748 to 1783 forty-nine newspapers, weekly and semi-weekly, were set up, but of all started between 1690 and 1783, only forty-three were extant at the time of the peace.

The first daily, *The American Daily Advertiser* (now the *North American*) came into existence in Philadelphia in 1784, and was followed in New York by the *New York Daily Advertiser*. In 1786 the Pittsburgh (Pa.) *Gazette* was founded, and still lives. A large number of unsuccessful papers now sprang up in succession, but few succeeded, nine being swallowed up by the Philadelphia *North American* between 1771 and 1848. Of many hundreds set up in New York alone, from 1725 to 1827, only two now exist, the *Commercial Advertiser* and *Evening Post*. The very names of defunct newspapers since 1690 would nearly fill the entire pages of one of our present dailies.

Prior to 1820, the editions of all papers were small and their production a work of difficulty. The publishers had to contend against bad and expensive paper, battered type, oily ink, uneven impression, and a host of minor vexations; the methods of printing were cumbrous and slow, news was not easily procured, and the absence of facilities for distribution (none being sold on the streets), combined with the other difficulties to keep editions small and prices high. Up to 1830

the regular price was twenty-four, sometimes twenty-eight cents. Another drawback to extensive printing was the fact that up to this time there were but two type foundries in the country, the first being that of Binney & Ronaldson in Philadelphia.

About 1835 Mr. (now the Hon. Byron) Weston instructed the wood-pulp inventors how to turn out their first sheets of writing paper, a most valuable improvement. The endless web of paper had been invented in 1804, but printing on it was not thought of till many years later. The old cumbrous wooden presses had been found quite inadequate about that time, and in 1807 the first iron press was set up by George Clymer, of Philadelphia. The Washington, Adams, and Hoe hand presses followed, and in 1821 the first power press was produced by Daniel Treadwell, of Boston, and was later used by the American Bible Society in New York.

After a year or two more than twenty power presses were in operation, and the first used for newspapers was employed in printing the *Boston Daily Advertiser*, and soon after was adopted in New York. One invention must always be succeeded by supplementary inventions to insure success, and the power presses led to the employment of composition rollers in 1814; prior to which time ink had been applied on leather balls held in each hand and rolled against each other over the type. The greater facilities for printing demanded a larger supply of type, and type foundries came one after another into existence. With the increased ease of production there came naturally a decrease in price, and in 1830 a paper appeared in New York with the innovation of local added to general news, and at the amazing price of one cent. This was the New York *Sun*, and in 1835 the New York

*Herald* appeared at the same price; the growth and prosperity of both having continued to the present day. In 1841 Horace Greeley and H. D. Sheppard followed suit with the New York *Tribune* at the same price; commencing their career on a borrowed capital of one thousand dollars, and with a subscription list of five hundred. This venture failed, not from any lack of editorial ability, but from financial difficulty. The *Tribune*, however, revived, and has been among the foremost of the great dailies in accepting improved methods. The original *Tribune* contained no more matter than to-day's *Tribune* holds on a single leaf, and a flat press turning out one thousand five hundred papers an hour was amply sufficient for the demand. Two or three men, working from midnight to six A. M., could get out as large an edition as was wanted. The stereotype was as yet unknown, therefore, the scope of the journal was very limited; there was no late news, no early sales, and no out-of-town circulation.

In this same year (1835), *The Baltimore Sun* and *Philadelphia Ledger* were established.

The conjoined influence of home news and low prices completely revolutionized journalism. A large number of newspapers gave more space to news and less to discussion, and all lowered their prices.

It was foreseen about this time that no single press would shortly be able to print the number of editions growing in demand, and it was found necessary to devise means of applying the papier-maché stereotyping process to newspaper work. The problem was difficult; for the utmost time a daily paper could allow for the entire operation of taking the matrix, drying, making a cast, cooling, trimming, and finishing, was half an hour. At last, after some years, Mr. Charles

Craske, of New York, arrived at a solution of the difficulty in 1861, and his plan was adopted first by the *Tribune*, just in time to enable it to meet the demand for increased editions consequent on the intense interest aroused in the public mind by the war. Other journals quickly took up the new process, and some editions at this period rose to the unprecedented number of an average of one hundred and sixty thousand copies per week.

The first web perfecting press capable of producing a large morning newspaper was built in 1861, by William Bullock, of Pittsburgh, for the *Cincinnati Times*, but it was several years before he produced the improved press capable of turning out ten thousand perfect papers an hour. The limit of number was found in the impossibility of delivering beyond a certain rate from the fly. In 1877, Richard M. Hoe and Stephen D. Tucker obviated that difficulty by the introduction of an accumulating cylinder, which increased the production to eighteen thousand per hour. Colonel Hoe's next improvement was the double cylinder, giving off two thousand per hour. This was followed by the lightning rotary press, with four to ten revolving cylinders, giving from four to ten thousand impressions per hour. Up to now, in all machines the separate sheets were fed by hand and delivered flat. The many-cylinder press was gradually abandoned as the perfecting press came into use.

The lightning rotary was soon followed by the Hoe self-feeding perfecting press, delivering flat sheets printed on both sides at the rate of twelve thousand papers per hour, while yet another improvement gave a machine that printed, cut, pasted, and folded at the rate of fifteen thousand per hour. The double perfecting press next made its appear-

ance, and was a great advance on all others, increasing the productive power to thirty thousand per hour, cut, pasted, and folded to one-eighth page.

The inventive genius of the principals in the Hoe establishment discovered even greater possibilities of achievement, however, and a double stereotype insetting press was the next step of these successive grand evolutions ; delivering papers, folded half-page size, with the supplements, if desired, pasted in, running at a speed of twenty-four thousand eight, ten, or twelve pages per hour. This idea of making a newspaper any of these sizes at will, the pages all made fast to each other, was found exceedingly useful, and was followed by marvelous results. A double stereotype insetting supplement press was made, turning out eight-page papers at forty-eight thousand per hour; also twenty-four thousand ten or twelve-page papers. The precision and accuracy of these machines is wonderful. Night after night, day after day, year in and year out, they run without wear or breaking, unceasingly producing the same exact results. The paper for Hoe's perfecting press is made in continuous rolls, of the width desired for any particular newspaper press, averaging about four miles in length. The paper having been dampened by an ingenious contrivance by which a spray as fine as mist is thrown on it, it is lifted from the wetting frame by a movable hoisting apparatus suspended over the centre of the machine so that its free end drops into the place that receives it. In the great quadruple press of the *New York World*, however, the huge roll of paper is placed near the floor, giving greater steadiness to the machine and more facility in handling.

The quadruple press just mentioned stands at present at the head of all printing machines in productive power ; but

where the development of the newspaper printing press will end, no man may venture to predict. Mr. Carpenter, of the Hoe Company, being lately asked that question only replied that whatever the future might bring forth, it could have no surprises for him. *The World* has the equivalent in this quadruple press of twenty single perfecting machines having a productive power of two hundred thousand eight-page papers an hour. Seventy-one men and boys now do all the work required in the press-room. To turn out the same amount of printed matter in the same time would require eight thousand screw presses producing twenty-five papers an hour, with a man and boy to each; eight thousand men and eight thousand boys; one hundred and eighty-five boys more would be needed to cut, paste, and fold. Other men and boys would be required for the various work of the press-room, so that no less than sixteen thousand five hundred men and boys would be needed to get out an edition of two hundred thousand eight-page papers in an hour. In such a case it is needless to add the work would not be attempted. No newspaper could afford rent for a press-room large enough to contain eight thousand presses and sixteen thousand five hundred workmen, not to speak of the item of wages: neither would any mill be required, as at present, to turn out forty tons of "news" paper in a day.

To the uninitiated, the quadruple press appears complicated and bewildering in appearance and action; but the makers, who ought to know best, declare it to be "essentially simple." From the moment the paper enters on its swift journey to that when it is delivered a complete newspaper by the folder, its course is direct and continuous, unassisted by a single human hand. A year was required for the building of this

machine, which is composed of six thousand five hundred parts, and weighs about one hundred and six thousand pounds, or fifty-three tons. The great roll of paper for the main press is about six feet wide, weighs one thousand seven hundred pounds, and requires two men with block and tackle to handle. The width of the margin of the printed page is regulated by a screw controlled by a hand at the head of the paper-roll spindle. A set of leather belts carry the papers out of the folding machine and automatically count them in piles of fifty as they move out of the machine.

This great press only requires three men and two boys to attend to it, but the noise it makes is terrific, rendering conversation utterly impossible. The invention of the triple and quadruple does not make the smaller perfecting presses any the less desirable, as these are in use all over the country in the smaller offices, and for daily papers of small circulation. About six or seven firms are engaged in their manufacture.

The very latest development of speed has been attained by a press now in course of construction by the Hoe Company for one of many enterprising daily publications, which prints, folds, pastes, and counts at the rate of ninety-six thousand four-page papers an hour, forty-eight thousand six or eight-page, and twenty-four thousand ten to sixteen-page papers.

The problem of having type set by machinery has for many years been present in the minds of printers, but although machines have been invented from time to time since the first one was patented in England by William Church, in 1812, few have gained any established success. Among the first used in America were those purchased by the founder of the *Chicago Times*, Mr. Wilbur F. Storey, who in conse-

quence of a contest with union printers resolved to dispense with the services of printers altogether if possible, but the machines did not prove a success. Early in the year 1888, a Louisville journal had trouble with their compositors, and adopted type-setting machines, which have succeeded, and that journal in a recent editorial says, "These type-setting machines are here to stay, and the sooner the typographic fraternity adapts itself to the revolution they are making in typographic art the better for itself and everybody else."

Several type-setting machines are in use among the newspaper offices of New York, and doubtless in those of other cities also. The latest invention is an electrical type-setting machine, by A. S. Capehart, of the Minneapolis *Tribune*, manufactured by the Minneapolis Electro-Matrix Company. One man in operating this machine can supplant at least five men setting type.

About the year 1830, the acquisition and dissemination of news having now become the chief aim of the newspaper publishers, the necessity presented itself of devising more effective means of procuring it. Expresses were established on railroads and steamers, and in remote places the "pony express" was called into requisition. Carrier pigeons were also used, but not found satisfactory. Boats were sent out to intercept incoming ships, and on one occasion a fast pilot boat was sent across the Atlantic, and special correspondents were sent to points of interest. The expense of all this provision for newsgathering was so enormous and competition became so eager that several journals combined in sharing expenses and benefits. An association known as the "Harbor News Association," for special news and chiefly confined to shipping, was formed. This happened before the electric

telegraph was an established success, but with the higher development of the telegraph the association expanded till in 1862 it was reorganized in its present form, or nearly so, and is now known as "The Associated Press." The Association is composed of the several papers, not of individuals owning or controlling them, and the proprietorship or policy of a paper may change without affecting its relations with the Association. It collects news, taking for the use of all its own members a common dispatch, reducing the cost to each by dividing expenses of reporting and telegraphing, and sells news at fixed rates to hundreds of other papers all over the continent. It has agents all over the world. Its London office is never closed, and news is cabled thence to New York as fast as it is received. It receives Reuter's collections of news from Europe, Asia, Africa, and South America, and has its own agents in North and Central America. In well-populated regions of the United States sub-associations are formed, which give the local papers fuller details of local affairs than are required by distant journals. The Pacific States, far removed from the activity of the Middle and Eastern States, and including a widely extensive country not densely populated, and whose interests are for the most part purely local, have an association of their own, supported by their own papers, which is quite successful. Notwithstanding this fact, the chief journals of California are liberal patrons also of the Associated Press of the United States. This partly accounts for the high price of newspapers in the Pacific States.

The influence of the aggregation of intellect and invention that in the concrete is generalized as journalism is unbounded. Fact, opinion, and comment, disseminated by means of mechanical inventions that so late as a century ago never en-

tered into our ancestors' wildest dreams, combine in the continuous education of the people long after school and college have done their work, and the reflex influence of the reading public on the men who daily supply them with information on every conceivable subject of human interest has aided in raising the profession of a journalist to a position of political and social power and dignity that would assuredly astonish the shade of Postmaster Campbell, of Boston, were he permitted to revisit the earth. One journalist has been Vice-President of the United States, several have been ministers to foreign powers, numbers are senators and members of the House of Representatives, and one has been a cabinet minister. In the Forty-first Congress there were eight editors in the Senate, and twenty-six in the House, the Speaker himself being one of them.

One striking feature of modern newspapers is the fullness of their reports of current events. The fullest newspaper report of the battle of Waterloo occupied only half a column of the London *Times*. In our day it would have spread to twenty or thirty columns. And to supplement written reporting, the newspaper of to-day adopts the practice of interviewing, whereby the minutest item of information is extracted by skillful questions from every one supposed to know anything about the subject to be reported, not always to the satisfaction of the person interviewed, perhaps, for when a practiced interviewer reads his "assignment" of work and sees the entry opposite his own name, "Interview Superintendent ——, (*must*)," the "must" means that the superintendent, whoever he may be, is to be interviewed and every scrap of information dragged out of him whether he likes it or not.

The growth of journalism as a profession has created a body of men of whom as a whole the country has reason to be proud. The half-illiterate, often intrusive and vulgar reporter of half a century ago has disappeared to make room for the intelligent, observant, and courteous gentleman who provides our daily feast of news in the most interesting and graphic form. He has been aptly called "the Froissart of his day." And not only are the reporters worthy of esteem for their literary work. The exigencies of their employment lead them into scenes of rural and city life where they are exposed to disease and danger which they meet fearlessly in the cause of duty; while in time of war, as well in other countries as in our own, the newspaper correspondents have shown a bravery of which military heroes might well be proud.

In the newspaper offices of the great dailies the exactness and precision required from the staff, and the perfect discipline maintained demands an amount of industry, self-denial, and strict attention to duty to which only a man of sterling character can respond. There is room for plenty of quiet heroism in a journalist's life, even though he may never become a war correspondent.

The editorial matter of the daily papers is chiefly political; but there are about five or six hundred newspapers (fifty in New York alone) that are devoted to the interests of religion, treating general news only when some topic of social or political interest impinges on their special field. Each is issued in the interest of its own particular denomination, and many of them are of considerable importance and extensive influence. The first successful religious newspaper was started in Boston by Sydney Morse, and named the *Boston Recorder*.

There is a fair proportion of illustrated newspapers, some showing editorial ability and artistic workmanship. Hundreds of comic journals have existed for a brief space, but very few have thoroughly succeeded. Those that have done so, however, are fairly holding their ground. Every trade and profession has its special organs with innumerable satellites; and in every department of the vast whole one of the most striking and influential features of newspaper work is the keen, intelligent criticism that is so valuable in directing the judgment and forming the opinions of millions of busy readers who have neither time nor inclination to examine for themselves the underlying strata of thought, fact, or statecraft that is brought to light by the patient and manifold labors of American journalism.

# MUSIC.

IN an age when among all civilized nations music asserts its claims on public attention more persistently than at any period of the world's history, thoughtful minds who from temperament or circumstance are outside the pale of the musical world are apt to inquire on what basis these claims are founded; what is the rational significance of music?

Such a mind, unbiased by the prevailing sentiment, unhesitatingly asserts that music has no distinct moral force; that the possession of musical gifts or knowledge confers no superior mental standing or moral tone on the musician; otherwise musicians, whether their gift be creative or exponent, would be persons of exceptional moral purity and refinement.

It is incontestable that music, of whatever order, appeals chiefly to the emotional nature; it is simply the emotional quality of sound; the study of sound being one of the most abstruse and intricate branches of modern science.

Music is not of human invention, but simply a human discovery; it is a part of the whole Kosmos, and musical sounds existed in the natural world ages before man discovered that he could attune his voice to melody.

The earliest cultivation of music is claimed for the Egyptians, Phœnicians, and Assyrians, the Hebrews no doubt gain-

ing their first musical culture from the Egyptians. The ancient Chinese regarded music as an important science, claiming for it, as did all the nations of antiquity, a divine origin. Their musical scale of five notes—symbolizing the five elements, earth, air, fire, metal, and water—was supposed to have been revealed to Ling Lung, a great musician, by a celestial vision. Kung, the grandest tone, was the sound produced by the rushing waters of the Hoang-Ho, and corresponded to our modern "middle F," which physicists tell us is the sound produced by the wind rushing through the forests. It is pathetic as well as grand, and is the prevailing tone of all natural sounds.

HANDEL.

It is scarcely too fanciful to suppose that the gentle melancholy produced in many minds by music is due to the preponderance of this majestic tone. "I am never merry when I hear sweet music," as uttered by Jessica, contains much food for reflection, and without a doubt in

my mind definitely expresses a true interpretation of the impression.

Grandeur and sweetness are the characteristics of the music of nature; it has been left for the coarseness of human invention to degrade sweet sounds in the service of frivolity.

Later in Chinese history, music held so important a place that Confucius said "Desire ye to know if a land is well-governed and its people moral, listen to its music."

GLUCK.

Egyptians, Assyrians, Hebrews, Chinese, and Hindoos, all believing in its divine origin, it followed that in ancient days the practice of music, like that of its sister-art, the Drama, was entirely confined to the priesthood of all religions; and the earliest schools were those of the temples, where all instruments were kept, as sacred things. In the account of King David's school of vocal and instrumental music, and his elaborate provision for the musical part of Jewish worship, the harps, trumpets, etc., are spoken of as "musical instruments of God."

INTRODUCTION OF VOCAL MUSIC TO ISIS.

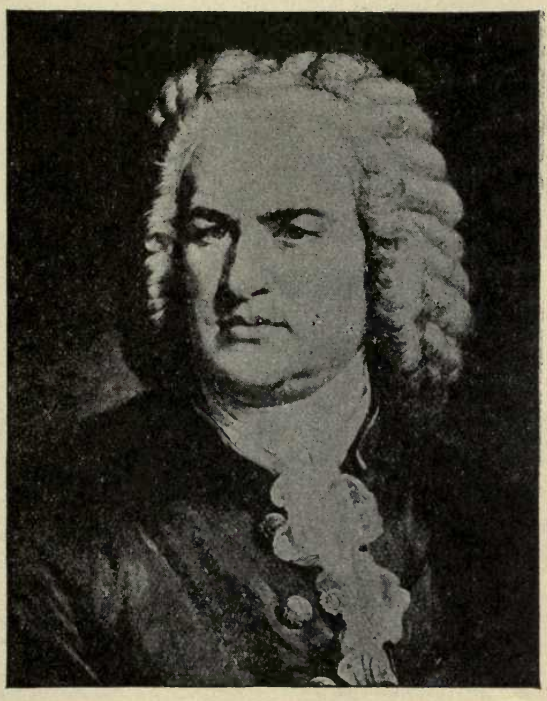
The ancient Egyptians taught that music was a symbol of the whole Kosmos, harmony being the ruling principle of Nature, and attributed the introduction of vocal music to Isis, the invention of the flute to Osiris. Egyptian flutes of very early date have been found in tombs, having seven notes, and there is no doubt that the Egyptian temple hymns must have been the models for those of the Hebrews, and also for those of the early Greek worship.

Early in her history, the emotional side of the national life of Greece was greatly influenced by the music learned from the Egyptians, which was rapidly assimilated by the quick Greek intellect, and elaborated far beyond the standard of its first teachers. Pythagoras especially enjoined the practice of music as a "means of purifying and elevating the soul." This early cultivation covered the mythic period up to about 1000 B. C.; the next stage, or classic period, from 1000 to 400 B. C.; and thenceforward there was a decadence of music until the supremacy of the Roman Empire. The Romans gave no attention whatever to music, except in its lowest form, as an adjunct to popular entertainments; and it was in danger of becoming a lost art, when the early Christians began to sing the hymns, partly founded on old Jewish melodies, partly on Greek chants, that laid the foundation of modern musical science.

As the primitive Christian worship developed into more elaborate ritual and æsthetic principles gained power, the people were gradually excluded from participation in the music of the Church, and in 330 A. D. Pope Sylvester established a school of vocal music in Rome. The study advanced but slowly, till Gregory entered on his great work of revising

the liturgy of the Roman Church, and developed the method of chanting known by his name. The two modes then in use—the Ionian, or C major, and Eolian, or A minor—became the principal modes of modern musical development.

A number of compositions were written at this period by priests and monks, but up till the twelfth century none of any real value were produced.



BACH.

Two extraordinarily antagonistic accounts of the Emperor Charlemagne's interest in music are given. The one states that he had a positive personal objection to instrumental music in any shape whatever, and wished to lower it from a state of decadence to absolute obscurity; and that from his fierce opposition arose a determination to revive it among the musicians of the day, which, though unenthusiastic at first, gained ground till music became a matter of national importance.

The opposite statement avers that Charlemagne was deeply interested in the true Gregorian Liturgy and its

introduction in the Church; and that he ordered a collection to be made of all the popular secular music of the time (768 to 814). He possessed an organ which Constantine had sent from Byzantium to his father Pepsin; and received a still finer one from the Caliph Haroun Alraschid.

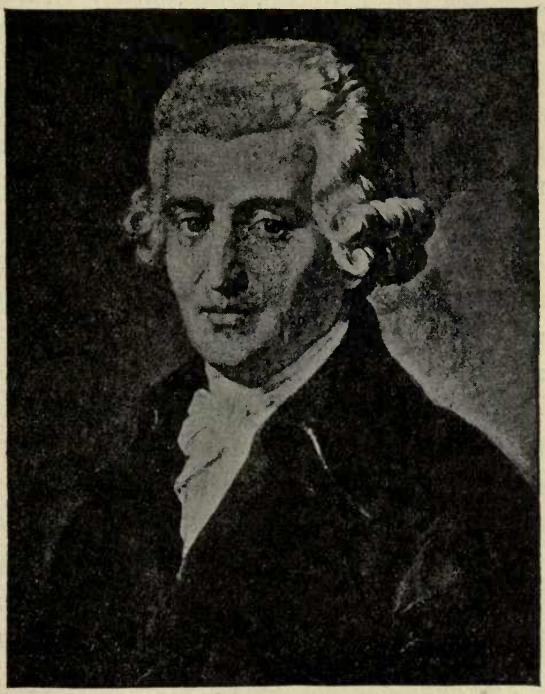
It is further said that Charlemagne on an Easter visit to Rome took his court singers with him, when they disputed fiercely with the Italians as to their respective rendering of the Liturgical music, the Italians declaring theirs to be the one true method. Charlemagne gave his judgment against his own singers, and employd Italian masters to restore the purity of style which he charged them with having corrupted.

The organ now played a great part in the development of music. Invented by Ctesibus, the Egyptian, between 284 and 246 B. C., it was at first played by hydraulic action. The inventor of bellows is unknown; but organs of this improved type were much used in Greece and Rome, and were made at an early period in England. St. Aldhelm, in the seventh century, speaks of one having the innovation of ornamental pipes.

The organs of our day, many of which have thousands of pipes, exhibit the largest amount of acoustic and mechanical power combined to be found in any machine of human invention.

Late in the tenth century, Guido, of Arezzo, added two lines to the staff then in use, and named the notes afresh from the first syllable of each line of a popular hymn to S. John, the Baptist. This innovation, dispensing with the complicated names of the old Greek notation, simplified the study of music, and gave wider range for the expression of larger and more varied ideas.

About this period, the time-table, invented by French churchmen, was introduced, giving an increased impetus to the study of music among all civilized nations. The principle of polyphonic harmony became better understood, and musical science steadily advanced till in the early part of the fifteenth century notation was fixed. The first compositions of any real value were written by a Belgian singer in the Sistine Chapel at Rome.



HAYDN.

Music now began to create interest outside the Church. The Troubadours or Minnesingers, who wandered about singing secular music with accompaniments of the mandoline or guitar, formed themselves into guilds, and in 1207 held a contest at Wartburg, in Saxony.

Italian musicians, of the secular school, now attempted to revive the lyrico-dramatic art of the Greeks; and the earliest production, in crude form, of what is now called opera, was at the marriage festivities of Marie de Medici and Henry IV. About the same time the first Oratorio "*L'anima e corpo*" was performed in a church in Rome

The invention and development of opera created a new musical era, Italy taking foremost rank, and her eminent mastery elevating their calling to the dignity of a profession.

The growth of national schools of composition was the inevitable outcome of the now universal spread of musical science. During the sixteenth century, Palestrina gave to the world those marvelous compositions that are still models of classical Church music. The Germans evolved their grand *chorales* from the older hymns, while the English developed the *Anthem* from the same source, and composed psalm-tunes that no later school has equaled.

At the beginning of the seventeenth century the popular taste for musical drama was increased by the organization of traveling companies, who so fascinated the public that it was not uncommon for part of an audience, perhaps some fifty to a hundred people, to follow a company to their next stopping-place in order to hear again the performance to which they had previously listened from four P. M. till midnight in their own town.

To the later seventeenth and eighteenth centuries belongs the honor of being the birth-time of the six great masters who with Palestrina (of the sixteenth) form the group of composers whose work will live so long as music exists on earth.

First in point of time was Handel, born at Halle, in 1685. At ten years old the professor who instructed him in music declared he could teach him nothing more.

It may be observed here, in parenthesis, that although each of "the great seven" developed unusual power at a very early age, their best work was done after middle age. Handel was fifty-six when he wrote the *Messiah*, and sixty-one

when he composed *Judas Maccabeus;* Glück produced *Iphigenia* at sixty-five, and Haydn the *Creation* at sixty-nine. What the divine Mozart might have achieved had he reached middle life it is impossible to imagine.

From the period of his first public triumph as a composer at fifteen, Handel's personal life was a stormy one. He was pursued by jealousy and intrigue in his native land, and while attaining much honor in England, the country of his adoption, was yet incessantly troubled by the cabals of enemies. But through all vicissitudes he kept his mind fixed on his great work, and produced in rapid succession forty-three Italian operas, ten German operas, a quantity of miscellaneous vocal and instrumental music, and twenty English oratorios.

It is related of him that while composing the "Messiah," he said that he never ventured to commence writing a single number without preparatory devotion, so impressed was he with the sacred magnitude of his theme.

About the year 1700, Italian opera gained a steady hold on popular favor, and henceforward we find the great masters giving their attention to works of that school. The noblest musical dramas ever written which have served (and continue to serve) as models for all others, were those of Glück, who wrote eight Italian and thirteen French operas.

Bach, the third of the great masters, is less known by gigantic work in oratorio and opera, but in instrumentation is almost without a rival, and, with Handel, evolved his majestic style from the examples given by their predecessor Palestrina. Haydn, the fifth star in the constellation, was the creator of the model of chamber music. Master of many styles, as witnessed by his fourteen Italian and ten Ger-

man operas, his nineteen masses, and numerous songs, he is yet most emphatically known as the exponent of the æsthetic importance of the sonata, which he evolved from the old dance-tune. His music is of a strongly imitative character, and the innocent gayety of his lighter movements was probably the reflection of his blameless life. He had great influence over his youthful contemporary Mozart, whose work, however, was in nowise imitative.

MOZART.

Mozart was born in Salzburg in 1756, and at five years old appeared in public as a pianist, and in a year after began composing. At ten years old he had advanced sufficiently to pay no heed to any criticism but that of the greatest masters of the time, and his versatile powers developed rapidly. A violin having been presented to him, in Vienna, as a tribute to his wonderful powers, he taught himself to play it on the homeward journey from Vienna to Salzburg, and on his arrival astonished his father and sister

by executing with perfect precision the second part in a trio.

To Mozart may be applied, more than to any one of "the seven," the epithet, "many-sided." In his influence on the emotional side of human nature he has no peer. That he excels in the expression of romantic sentiment is no wonder, for his short, sad life, with intermediate spasms of gayety, was itself a romance. He wrote from the heart, and therefore touches the heart. But his music has a more earnest side than the romantic; beside his brilliant operatic work stands his invention of the orchestral fugue (an intellectual labor of no mean kind), and the weird grandeur of his religious works. The modern world knows Mozart chiefly as the composer of "Il Don Giovanni," king of operas, and the imperishable "Requiem;" but a lifetime might be spent in study of his less known works, replete as they are with captivating melody, exquisite harmony, and unapproachable purity of feeling. Of his fourteen Italian operas, "Don Giovanni" will be immortal for its marvelous combination of grace, gayety, and dignity and symmetrical structure, while "Belmont" and "Der Zauberflöte" are models of modern German opera.

Beethoven, whose life extended into the present century (he died at Bonn, 1827), entered upon the time that saw the separation of the German and Italian schools of music, but in his own compositions intensified both schools. He, with Clementi, the founder of piano-forte playing as a distinct branch of music, promoted greatly the perfecting of that instrument. He wrote but one opera, one oratorio, and two masses, but the list of his piano-forte works, sixteen with orchestral accompaniments, is almost endless. For grandeur

and strength, Beethoven's works are unequaled. They also have the remarkable property of admitting diverse interpretations, all equally sublime, and thus will appeal to the heart of the world in all ages.

The earliest mention of the piano-forte, evolved by gradual stages from the poor little dulcimer, is in 1598. Its mechanism was continually improved by English makers, and its adoption helped to popularize secular music. Clementi and Haydn did much to insure the popularity of the instrument, but it was left to Beethoven to compose the ideal music for it, music which as yet is but imperfectly understood.

The history of music in America is necessarily brief. From 1620 to 1771 there was scarcely anything in the shape of music existing. Puritanic hatred of the fine arts confined vocal music to the execution of psalm-tunes, and instruments of all kinds were looked on with disfavor. The first American composer was William Billings, of Boston, whose talent was devoted to producing psalm-tunes, and who first introduced "viols" into the Church. He had many followers, men who composed "tunes" to any extent, in any style that occurred to them, with a calm defiance of all rules of the art. The clergy opposed the new style of "fuguing tunes," but they were popular and were the staple element of music, at least in rural districts, for many years.

The first impulse in the direction of musical culture was given by the formation of the Handel and Haydn Society, of Boston, who gave oratorios even before 1800. New York established a musical society about the middle of the last century. In 1750 the first opera was performed in New York, and in 1791 French opera was introduced at New Orleans. With the progress of musical culture in America

many now world-famous names are associated. Theodore Thomas, who came to this country at ten years of age, established his great orchestra in New York, in 1861, and traveling to Cincinnati in 1869, was very successful, and was head of the Musical College for many years. In 1880 he returned to New York to conduct the National Opera.

In 1825 an attempt was made to establish Italian opera in New York, with limited success. Subsequently Manuel Garcia, with a brilliant troupe, endeavored to achieve popularity, but without permanent results. As yet, Italian opera has found no abiding home in America.

The most popular opera singer of native birth was Ann Louise Carey, introduced by Mapleson. The most costly opera was produced by Strakosch, the cast made up of foreign stars. The best operatic company now existing is the Boston Ideals.

The first American prima-donna who has achieved a high popularity in Europe is Clara Louise Kellogg.

Although orchestral music has a high place in the affection of the musical world, piano-forte playing is the favorite musical diversion of the people. Its adaptability to the ordinary tastes of the majority and the essentially domestic enjoyment it provides, account easily for the fact that in the United States there are more pianos and pianists in proportion to the population than in any country on earth.

# POETRY.

AMONG the arts, Poetry stands in the forefront, as being in all its developments the complete and perfect medium of conveying thought from mind to mind. That this truth has been recognized in all ages by civilized man is evident from the fact that every nation in turn has conferred on its greatest poet the epithet "divine."

The subjects, style, and aim of poetry both in ancient and modern days have varied with time, circumstance, and the movement of national thought and life; but its pre-eminence among the dominant forces of mental life, as the exponent of the highest ideas conceivable by the human intellect, remains unchanged.

Modern poetry differs from that of the ancient world mainly in the definiteness of its aim, this definiteness having been engendered in course of time by the growth of critical inquiry incident to the higher culture of the day. Ancient poetry was by no means devoid of aim; but the writers of the older time, less influenced by strict canons of poetic law, with a narrower range of world vision, and less expectation of searching criticism, exhibited less harmony and cohesion of poetic structure, while necessarily employing the peculiar

combinations of action, rhythm, and rhyme indispensable to the production of a poem.

Notwithstanding the lofty standing of Poetry as an art, perfect intellectual appreciation of a poem is not a necessary factor in its influence on the mind. It is quite possible that a reader may not thoroughly enter into the full depth of meaning or mentally grasp the complex composition and artistic quality of a great poem, and yet be profoundly influenced by the general sentiment pervading it.

Is the intention of Poetry, as generally understood, to instruct, amuse, or has it a still higher object?

Aristotle was the first to write philosophically on the art, and he considered its culture the chief means of elevating thought, viewing it as an energy and recognizing its value in relation to other expressions of spiritual force.

Poetry demands the highest place in art because it is less vague than music, more fitted to interpret the ideal than painting, more enduring than sculpture. It does not depend for existence on mechanical power as do these others. The sculptor is helpless to evolve his thoughts from the marble without his chisel; the painter can reproduce no vision on canvas without his brush and colors; the musician can express no harmony without the aid of instruments; but were every implement of writing and accessory of the stage swept out of existence, the poet could speak, and his utterances live from age to age in the hearts of the people; for the emotion produced by words is held by the memory more persistently than that produced by sound. As one of the primal human forces Poetry has had as much effect in determining the destiny of man as science. Emotional in its nature, it is concrete in form, expressing the effort of the mind in rhythm.

In all nations Poetry invariably precedes prose in their literature; the imagination of a nation, as of a child, being earlier in development than reason.

The earliest Poetry of which we have authentic record is that of the Hebrews, the first poem handed down being the Song of Triumph written by Moses after the passage of the Red Sea, and taking rank as poetry rather from the rhythmic movement of ideas than their expression in syllabic measure. This majestic movement of rhythm without rhyme is also found in the Psalms, the finest known collection of lyric poetry, exhibiting by turns vivid descriptive force, heroic sentiment, delicate imagery, and intense pathos. Passages of grand vehemence and passion occur in the poems scattered through the book of Jeremiah, written at the same period. The power of the ancient Hebrew poetry, and its influence over men for three thousand years springs from its own internal force and its intense sympathy with the actual condition of the human race in all ages.

The earliest epic and dramatic poem in the world is the Book of Job.

Next in age to the Hebrew stand the wonderful poems of the Hindû people. Their Vedas, dating about 1500 B. C., consist of hymns, prayers, rules for religious rites, and moral teachings, all written in song form. The Vedas are varied in style and matter; are epigrammatic, didactic, epic, descriptive and dramatic, but are wanting in the grace of the Hebrew lyric.

With the development of the Sanskrit language, Hindû poetry became rhythmical and metrical, following the eight-syllable method which is the source of all metre. Of this class of poetry is the Ramayana by Valmiki (period unde-

termined), in seven cantas, containing twenty-five thousand verses. Exceeding fine lyrics are found in the Mahabharata, the product of a period, consisting of two hundred thousand verses. The didactic poetry of the Hindûs covered a wide range of subjects, and dealt with every phase of human existence, including such writings as law-books, school-books, deeds, dictionaries, and inscriptions. Their dramatic poetry first flourished about 300 to 400 B. C., and was of a moral and religious character. Serious and comic pantomime and music were employed in its representation, and all performances concluded with prayer.

The ancient Persians, in keeping with their warlike character, only boasted one great poet, Ferdusi, who wrote a grand epic about 1000 B. C.

The ancient Chinese idea of poetry was the production of short moral sentences in consecutive order, as seen in the writings of Confucius and his predecessors. They had neither epics nor pastorals, and rhyme and quantity were given simply by tone.

With the growth of Greece and Rome as intellectual centres there sprang up new forms of thought, finding expression among the Greeks in exquisite lyric forms, while Rome rejoiced in her three great tragic poets, and many who wrote in lighter strains.

With the decline of these magnificent civilizations there was a long eclipse of true poetry, until its spirit emerged slowly into the light of the thirteenth century. The fusion of nations during the Dark Ages contributed to the creation of a new school by the Italians. Poetry became the fashion at the courts of Frederick II and Charles of Anjou, the latter monarch and his sons distinguishing themselves as writers

of verse; and Italy held first place as the home of the poetic muse until the end of the fifteenth century.

Meanwhile, the French had cultivated lyric poetry, made popular by their troubadours, and always of the highly romantic school; and England had produced the greatest of her mediæval poets, Chaucer. Germany had few poets at this period, and their writings were rhymeless, but alliterative in form. The Scandinavians clung to their ancient poetic hymns in praise of the gods and the splendid epics known as the Sagas.

The earliest instance of rhyme in Oriental poetry is found in a pastorial poem by Lebid, written before the time of Mahomet, with whom Arabian history begins, in 622 A. D. For ninety years the Arabs had no poetry except that found in the *Koran*, in which morality, theology, jurisprudence, and domestic life are all treated of in poetic strain. The tendency of the Mohammedan faith to isolate its believers, in thought, from the rest of the world, prevented their becoming acquainted with the Greek drama; and their poetry never rose above the level of commonplace; the large number of words with similar terminations in the Arabic language contributed also to this low average of composition, rendering it easy to hide feebleness of thought under the melodious jingle of easy rhymes. Consequently, the Arabian poets never produced an epic, a comedy, or a tragedy. Their poetry was all lyrical, and outside the *Koran*, was chiefly the language of the passions.

Though the darkness of the Middle Ages had been illumined by Chaucer, Dante, Petrarch, Ariosto, Tasso, and a few lesser stars, the stormy moral atmosphere of Europe was unfavorable to the development of poetic sentiment among

the masses of the people until in the sixteenth century Germany aroused herself to study the ancient classics, and a lyrical school arose who provided the awakened Church with hymns and chorales.

In England, about the same period, poetic feeling began slowly to permeate the intellectual life of the nation; a higher and more truly poetic sentiment was exhibited by the dramatists, reaching its culminating point in the works of Shakespeare, the widespread influence of whose writings is a proof that perfect intellectual appreciation of poetry is not essential for the proper enjoyment thereof.

In his most popular plays—as "Othello," "Hamlet," or "The Merchant of Venice,"—we are influenced by the presentment of the mental characteristics of their heroes, and their moral action in varied and crucial circumstances; this influence always tending toward good, the moral teaching being of the highest character.

For instance, in "Othello" we see a noble warrior, dethroned from the high pedestal on which his achievements had placed him, by the maliciousness of jealousy. His dethronement is complete, and while admitting it to be warranted, we feel a pang of regret for his misfortunes and a deep scorn for the traitor who caused them; sentiments that exert an influence for good, no matter whether we have or have not followed and fathomed the intellectual intricacies of the play as a work of art.

An opposite influence is exercised by the representation of a bad character. We neither pity nor feel regret for him when he meets his final deserts, and are correspondingly roused to a sense of injustice when villainy prospers, the honest mind revolting against that which seems unfair. It is

therefore obvious that the heart which creates such impulses, whether it seeks to reach us through the simple channel of reading or the attractive environments of the stage, must wield a tremendous influence for good; and not on the cultured element in a nation only.

A striking instance of the deep influence of the higher poetry of the drama on persons of low intellectual attainment was seen in the success of Mr. Phelps in raising the moral tone of a section of the population of London by the presentation of the higher drama.

Impressed with keen regret by observing the immense audiences that thronged the Sadlers' Wells Theatre (in a district inhabited exclusively by an uncultivated vulgar class of people) to enjoy coarse and commonplace plays, he resolved to educate them. He took the theatre himself, and produced the finest plays of Shakespeare and the later dramatists; he soon drew larger crowds than ever of the very same class of the community, established order and good manners, and in a very short time Sadlers' Wells became as noted for the quiet, critical enjoyment of its audiences as it had once been for their boisterous vulgarity. Yet it cannot be questioned that not a tithe of these people could have had thorough intellectual appreciation of the poetic dramas they learned to enjoy.

Since Shakespeare's day the influence of modern poetry has steadily advanced in Europe, and illustrious names on the roll of poetic fame are neither few nor far to seek. Force and enthusiasm in Germany, vivacity and delicate shading of sentiment in France, and sensibility and pure thought in England have all had their exponents. It remains yet to be seen what will be the informing and indwelling spirit of the poetry of America.

The youngest of western nations, her national school is still in process of creation; but in her poetic efforts she has evidently taken heed to the Apostolic injunction, "Let no man despise thy youth," for her leading poets have already attained world-wide fame.

In our poetic literature the Northeastern States have taken the lead from the very earliest settlement of the Colonies. From the commencement of their history, the students of Cambridge, Mass., cultivated poetic taste, and were the first to earn for their State the title of "the home of American Poets."

Virginia, "the mother of Presidents," might have been "the mother of poets" also, but for her adherence to the feudal policy of dispersion, which placed a ban on learning within her borders.

The reverse policy being pursued in Massachusetts, the reverse influence of course was felt; the pre-eminence of Boston (which eventually became the State capital) in the development of culture and poetic thought—whereby she has gained the *sobriquet* of "Hub of the Universe"—being undoubtedly due to the influence of the men of pre-national times.

The very idea of the South is of itself suggestive of poetry, but the Southern States have not as yet established a claim to be the birthplace of poets, very few having made any great mark except Edgar A. Poe, to whom literature is indebted for fully one-third of the poems written by Southerners.

It is difficult to judge of the actual potency of the influence of contemporaneous poetry from the fact that fashion exerts a baneful influence on all arts in every age. While the ear is

receiving impressions from the combined sounds of a great orchestra, it is scarcely possible to decide on one particular instrument whose tones will linger longest in the memory; and so it devolves on the next age to pronounce on the enduring qualities of the poet's work. The number of American poets is small, probably because ours is a specially critical age, and critical periods are in the main uncreative.

The stirring time of the Revolution brought forth a ballad literature that was as voluminous as it was patriotic, and some of the songs were of great merit, becoming as well-known in England as in their native land. When quiet settled down on the newly-created Republic, men had more leisure for the higher literature, and thenceforward poetic culture has rapidly advanced.

Among the first to inaugurate a *Home* school of poetry in this country were Washington Irving, Mrs. Sedgwick, and Longfellow. Horace Greeley said that Whittier was the first genuinely American poet, and it must be admitted that he was pre-eminently the poet of his own historic generation. He gave expression to the dominant ideas of New England life, and was the poet of a section whose movements ultimately became the governing impulse of the nation. He has in especial the typical American gift of wide sympathy and fluency of speech.

The period of the Civil War, with its fierce moral and emotional conflicts, stirred the patriotism of poets on each side, and the series of war-ballads that became popular show an immense advance on those of the Revolution, both in patriotic sentiment and true lyrical poetry, and some of them show a dramatic force which is utterly wanting in their proto-types.

The poetry of a nation must needs rise with the rising tide of its power, its influence, its intelligence and refinement; and signs are not wanting that devotion to foreign or sectional types is waning; that fresh poetic energy, beauty, and creative force is growing with the nation's growth, and that there is a distinct movement toward a school of poetry in America that will not only be national, but worthy of its birthplace.

The representative poets of the nineteenth century in America are Bryant, Longfellow, Poe, Whittier, Lowell, and Whitman; while of minor lyrical writers there are quite a number who are exerting an appreciable influence on the literature of the day.

William Cullen Bryant was born at Cummington, Mass., in 1794; and his early years were spent among favorable surroundings for the development of the poetic gift which distinguished him while yet a child. The scenery around his home was of exquisite and diversified beauty, and he had the advantage of home-training, calculated to draw out what was in him of pure and elevated sentiment. His father was a surgeon of studious habits, who himself excelled in writing humorous and satirical verses, and was a severe and faithful critic of his son's work.

At ten years old, Cullen (as he was called in the family) wrote an address for a school examination, in heroic verse, which was afterward published in the New Hampshire *Gazette*, and became a stock recitation piece in New England schools. In his twelfth year he wrote a poem on the eclipse of the sun, wonderful for a child-poet; but his father, with his usual kindly severity, told him he would "be ashamed of it some day." The boy wondered why, and set himself to find out. Trained in the rigid faith of Calvinism, Cullen believed

firmly in the efficacy of prayer, and records in his fragment of autobiography that at this time he was accustomed to pray "earnestly for the gift of verse."

His literary path even then was not over smooth, for his grandfather, of whom he stood in great awe, was accustomed, whenever he noticed the delicate lad resting occasionally as he worked, on the farm, to taunt him with the inquiry: "Stopping to make verses, Cullen?"

In 1809, he began studying Greek and soon exhibited passionate love for it, learning so fast that the next year he entered Williams Colloge as a Sophomore.

Seven months after, he left college and commenced studying law, and the poetic fire slumbered awhile. Licensed to practice in 1815, he returned to Cummington, and spent much time in communing with nature, the fire being thus fanned again into flame.

After a few years he abandoned the law, and settled steadily into literary life; his poem "Thanatopsis" having been published in the *North American Review*, and attracted much attention.

From 1823 to 1825 he wrote the "Thirty Poems," which brought him still more fame, and a year or two after went to New York to engage in newspaper work.

It is interesting to note that about this time Bryant wrote a favorable criticism on three poems of Longfellow (which appeared under the new poet's initials only, in the *U. S. Literary Gazette*), not knowing the author.

His editorial work created a poetic blank, which existed till in 1831 he published a volume of all his poems written within ten years. These were received with great favor in England as well as America.

In 1842, he published fresh poems, and undertook fresh editorial work. Mr. Bryant had a passion for traveling, and in this year made an extended tour in Europe, followed by others of wider range in other years. He highly appreciated the poetry of Longfellow, and was on terms of friendly correspondence with him throughout his life.

Though taking an active part in political life, thoroughly enjoying home life on his farm in Long Island, and frequently making long journeys, the poetic element was never kept in abeyance in his active mind. Indeed, politics and poetry seem to have had alternate place, or kept side by side. In 1864 another volume of "Thirty Poems" appeared, containing some of the longest he had ever written, and was well received; and following on this poetic work came his greatest political speech, delivered in April, 1865, at the Union League Club, on the announcement of peace.

In July, 1865, Mr. Bryant experienced a terrible grief in the loss of his wife, but his sorrow had no power to crush his indomitable spirit of activity. He made another long journey to Europe soon after, and on his return began a translation of Homer, and wrote several fine hymns. His translation of the "Iliad" met with great success and he then set to work on the "Odyssey," completing it in 1871.

The chief event of his serene old age was a public reception tendered him by both Houses of the Legislature at Albany. It was noticeable that as he advanced in years whatever irritability or asperity had been noticed in him dropped away, and his character in his later days was marked by gentleness and unselfishness.

In 1878, in consequence of a fall, the active, useful life of the first of America's true poets ended; and the country

mourned the loss, not of one of her favorite poets only, but of a patriot of lofty aims, a noble and faithful citizen.

Edgar Allan Poe claims distinction emphatically as the poet of wild imagination and original conceptions. He himself exalted imagination as the chief qualification needed by a poet, and contended that beauty was the sole object of verse.

The wild, irregular music of his poems has a strong, original charm, the harmony of idea and expression being complete even in the strangest metrical forms. Much of this peculiarity of style may be accounted for by the circumstances of his romantic life.

Both his parents died when he was a little child, and he was adopted by a wealthy merchant of Richmond, Va., who gave him his own name of Allan. When he was about six years old, Mr. Allan placed him at school in England, where he remained five years, and then accompanied his patron's family back to America. He is described at this time as a clever boy, of reserved and capricious temperament, and fond of athletic sports. When about fourteen, he formed a deep attachment for the mother of one of his school-fellows, who exercised great influence over the motherless lad, and from the poignant grief he experienced at her death he himself dated the birth of his first poetic impulses.

Three years later, he entered the University of Virginia, and might have taken highest honors had not his excessive love of sport and cards interfered with study. On leaving college, Mr. Allan placed him in his own office, but his natural restlessness and idealistic temper made the life distasteful, and he went off to Boston to take life in his own hand.

There he published a volume of poems, in 1827, that had

no success, and, finding literature unprofitable, enlisted in the army. After awhile, he made known his position to Mr. Allan, and was honorably discharged. In 1830 Mr. Allan sent him to West Point, but he disliked the routine work, and purposely neglected his duties in order to get himself cashiered. He has been spoken of by his comrades as kindly, but excessively shy and reserved, and making no friends.

Just before leaving West Point he managed, by subscription among the cadets, to publish another volume of poems; but it was received only with ridicule.

He resolved to go to the South, and in Baltimore lived a hard, struggling life, only cheered by the society of his aunt, Mrs. Clemm, whose beautiful daughter he married while she was still a child of fourteen, and to whom he was devoted till her death. Removing to Richmond, he there became editor of the *Southern Literary Messenger* for a short time, and subsequently engaged in editorial work in Philadelphia. There, as elsewhere, his peculiarities and his sharp and biting criticisms, with his inveterate habit of setting himself up as censor of better-known men, prevented his gaining friends among literary people, and he ultimately went to New York, apparently with no more definite object than that of making a fresh start in a new place.

For ten years, in adverse circumstances, but with indomitable spirit, he wrote industriously, but with no adequate financial success. His genius was fully acknowledged, but his unhappy faculty for making enemies by bitter attacks on the editors and poets who were his contemporaries was a barrier to attaining any social position. His wife's health began to fail, and his own gave way at length under the perpetual strain to which nerves and brain were subjected; one of the most

piteous facts known of him being that he suffered the more from denying himself absolute necessities for the sake of the dying girl.

Another poet has said:

> "Most piteous among all pitiful things
> Is the end of a thwarted life,"

and the words might have been written concerning Poe.

Though he began work again soon after his wife's death in 1847, his fitfulness and uncertainty still hindered success; and after many vicissitudes, having formed a marriage engagement, he started for the South to be married in July, 1850. He reached no farther than Baltimore, however; having been taken ill on the train. He appears to have wandered around in Baltimore for a few days, and it is believed that he was drugged by politicians who made him vote at several places; for he was found unconscious near a polling place, and being removed to the Washington Hospital died shortly after his admission.

His prose tales, powerful and weird, often mystical, secured for him a wide and lasting popularity in France. In England and America his widest popularity was attained by the well-known "Raven," which is unique, like the "Ancient Mariner" of Coleridge. Among his less popular poems there runs a vein of melancholy, a deep, almost passionate self-consciousness, and glimpses at times of a higher faith than is suggested by what is known of his life, although the best of them show little sympathy with ordinary humanity, and small regard for the vital interests of life.

Nevertheless, his wonderful facility of expression, visions of beauty, and above all unrivaled originality secure him his

high place among our representative poets. A memorial to him has been erected by the school teachers of Baltimore, and another by the actors of New York, in the Metropolitan Museum.

No two lives, no two literary celebrities, could afford stronger contrasts than do those of Edgar A. Poe and John Greenleaf Whittier.

Born at Haverhill, Mass., in quiet times (December, 1807), his parents being Friends, Whittier spent a serene childhood and led a quiet home-life on his father's farm until his twentieth year, when he went for two years to the Haverhill Academy. As a child he gave no sign of precocity, though extremely intelligent. In 1829 he became editor of the *American Manufacturer* in Boston, and the next year went to Hartford, to edit the *Northeastern Weekly Review*. Returning in a year or two to Haverhill, he was a member of the Massachusetts Legislature during 1835–6, and became Secretary of the Anti-Slavery Society. In 1838–9 he edited the *Pennsylvanian Freeman*, in which capacity his high ideas of patriotism and advocacy of humane principles earned him much opposition, which culminated in the burning and destruction of his office by the mob.

Whittier had now begun to write a great deal, both in prose and poetry, chiefly in support of his anti-slavery views. In 1847, while still writing much poetry, he edited the *National Era*. At this period a large number of his poems, inspired by current events, assumed a distinctively national tone; but in the greater part of his productions the charm lies in their exquisite poetic sentiment. In these his intense love of nature is conspicuous—but his nature is American all through. He sings of that whereof he knows. His flowers

and birds and streams are those of his own land, and we feel that the lessons they teach are lessons he himself has learned.

In the late autumn of his long and useful life, Whittier still wrote, preserving the beauteous spring-tide in perennial freshness.

Henry Wadsworth Longfellow was born in Portland, Maine, in 1802; a birthplace peculiarly fitted to exert a beneficent influence on the mind of a thoughtful child, to whom the lively stirring events of every day in a sea-port town are of unfailing interest. The picturesque beauty of the town, and the charm of the society existing there in the opening years of this century were doubtless large factors in the development of Longfellow's poetic instinct.

His boyhood was very happy, and he was remarkable for quiet intelligence and the sweetness of his disposition. His first poetic efforts were made when he was about thirteen. In 1822 he entered Bowdoin College, and while there his literary tastes developed more strongly, and his faculty for thoroughness became marked.

In one of his letters at this time occurs the characteristic sentence, "Whatever study I am engaged in I must devote my whole soul to it. I will be eminent in something."

In 1824, when the question of his adopting a profession was mooted, he wished to devote himself to literature, but his father demurred on the ground that it did not offer sufficient promise of support; however, he compromised by allowing his son one year at Cambridge for literary studies.

Just at that time the trustees of the college established a professorship of modern languages, and offered the position to the young Longfellow, who was already distinguished as a

student and writer. This led to his visiting France, Spain, and Germany for special study, and on his return he took up his residence at Brunswick, and commenced his work at Bowdoin. He was then, though but twenty-two years of age, considered the most accomplished student of modern languages in America, except W. George Ticknor, of Harvard.

Thoroughly devoted to teaching, Prof. Longfellow exercised great influence over his students. He published some articles in the *North American Review* about this time, but had for some time relegated poetry to the background. In 1834, however, he removed to a wider sphere. He was appointed to succeed George Ticknor at Harvard; and spent a preliminary year in Germany, Denmark, Sweden, and Holland, mastering the language of each country in that time, with Finnish.

During this journey Mrs. Longfellow died, at Rotterdam, and from the period of depression which followed his loss, he was aroused by the cheerful presence of William Cullen Bryant, whom he then met; and he was encouraged to take up his studies again.

The touch of sorrow aroused once more the divine gift of poesy, and having returned to America and made Cambridge his home, he published *Hyperion*, followed soon by *Voices of the Night*, of which Hawthorne said: "Nothing equal has as yet been written in our Western world."

Longfellow still continued teaching, but gave much time to poetry, and rapidly became the best known and most widely read of living poets.

In 1842 he sent forth his *Poems on Slavery* in a thin volume that was heartily approved and as heartily con-

demned, its object being more the expression of moral sentiment than the expression of poetic feeling.

In 1843 Mr. Longfellow married again; his union with the daughter of Mr. Nathan Appleton of Boston being an exceptionally happy one, and his life becoming one of unbroken peace for many years.

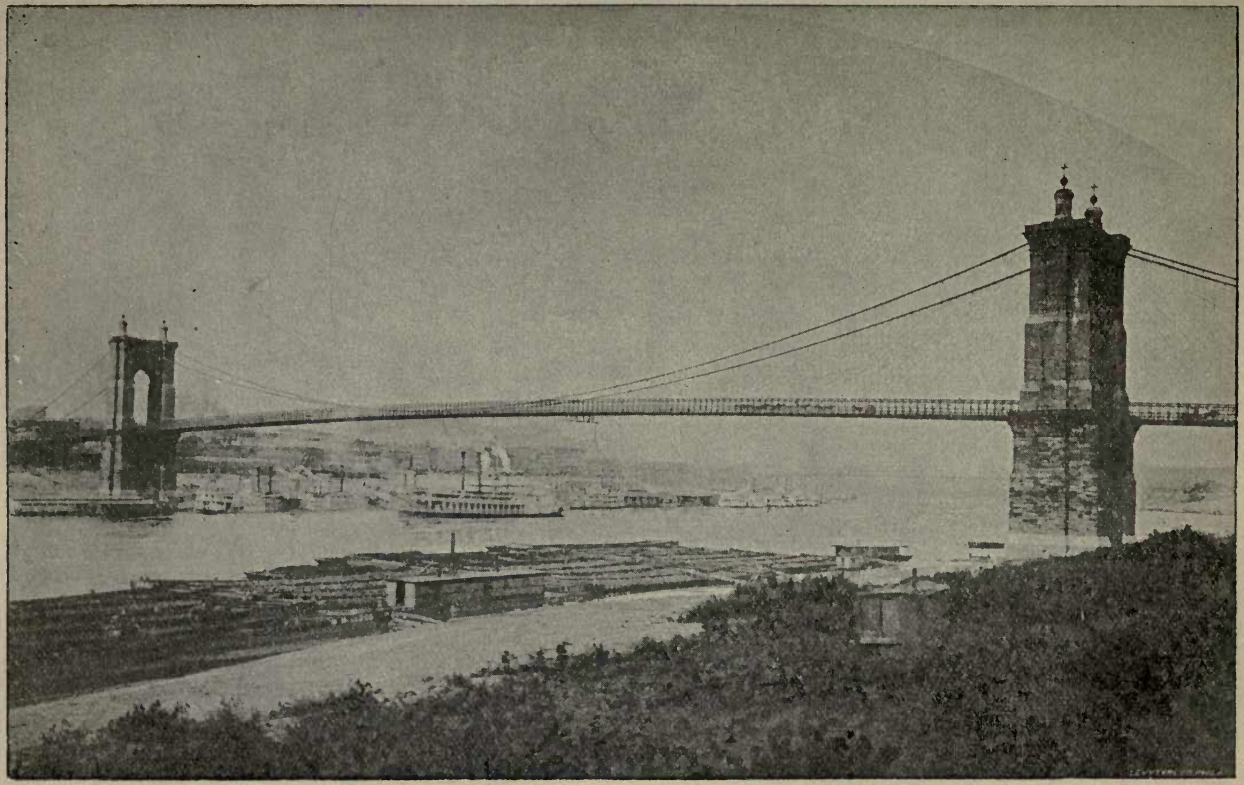
After eighteen years' work, he resigned his professorship at Harvard, and gave himself entirely to writing.

The first fruits of his leisure was the marvelous *Hiawatha*, that added fresh laurels to his fame.

In 1861 his literary work was laid aside in consequence of the shock attendant on the sad death of his wife by fire. After awhile, he took up the task of translating the *Divina Commedia* as a distraction from sad thought, which after four years' work was published, and immediately pronounced the finest translation of Dante in the English language. From 1867 onward to 1880, he published new poems, all instinct with the fire and vigor, grace and melody of earlier days; and wrote his last lines only a few days before his death, in March, 1882.

In England his death was mourned as a calamity; and in 1884 a bust of him was placed in the poets' corner in Westminster Abbey; the first time such honor had been paid to an American poet.

In both England and America, the purity of the life that expressed itself in such pure, sweet utterance was felt and honored, and to the majority of English people, Longfellow will long remain their ideal of an American poet.



SUSPENSION BRIDGE, CINCINNATI, OHIO.

## SUSPENSION BRIDGE.

WE have stumbled upon a pathway—a pathway lifted from the dead-level of commonplace existence by bold spurs and peaks of thought and achievement: beginning in the dim distance with the inevitable cradle rocked by the hand of love, climbing precipitately as it grows in the perspective from the sunny meadow lands of pastoral existence into a region of perpetual struggle up opposing heights, till, at the very inception of a bolder ascent up a highest height, it ends, falling abruptly out of sight into the dark valley of the shadow of death. Who traced this pathway, at whose finis stands in monumental grandeur one of the most brilliant achievements in engineering skill? Who is this who has dared to think and clothe his thought in forms whose utility and whose magnificence make equal demands upon our gratitude and admiration? Search must be made for him among the annals of the dead, and whatever laurels there may be for him must be laid upon the unfeeling stone that covers him, and that bears cut into its marble heart the name of John A. Roebling. This is the end—a grave—a grave cherished in the bosom of his adopted land, America, while Mülhausen, in Thüringia, Prussia, with just pride claims him as her native son. There was he born, June 12th, 1806; there was he trained in the schools, during early

boyhood, to habits of industry, and, later, by contact with a thoughtful people, to thorough self-conquest and masterful self-reliance.

Going from Mülhausen to Berlin, he there attended the Royal Polytechnic School, and, on the completion of his studies, received the degree of civil engineer. Required to devote three years to the service of the State, he sought and found employment in the public works at Westphalia. On the completion of his three years' term of service, Mr. Roebling, now twenty-five, began to look about for some permanent position congenial to his habits of thought and worthy the outlay of strength he felt to be his. His native land offering nothing immediately convincing to his judgment, and the new America appealing strongly to him with her wide and untried fields of labor, he yielded, and took the final step that transferred him from the Old World to the New.

He settled near Pittsburgh, and notwithstanding his tastes and education pointed to other employment, he returned, forced, perhaps, by immediate necessities, to primitive methods of gaining a livelihood, and for several years wrested from the soil his needful sustenance. This could never have been congenial employment, and, abandoning it, he obtained the position of assistant engineer in slackwater navigation on the Beaver River, in Ohio, afterward becoming engineer on Sandy and Beaver Canal.

Railways momentarily growing in favor, Mr. Roebling seized on the popular prejudice, and began surveying lines of railway across the Allegheny Mountains. In three years he surveyed as many lines, connecting Harrisburg with Pittsburgh.

In the interval following these labors, he began the manufacture of wire rope, introducing into America a new mechanical agent of vastly superior strength and durability. He first used it on the portage railway on which canal boats were carried across the Allegheny Mountains.

His first idea of suspension bridges was developed at Pittsburgh in 1844. The wooden aqueduct of Pennsylvania Canal becoming unsafe, the erection of a new one became imperative. The contract was let to Mr. Roebling, and specified that the work should be completed in nine months, including the winter season of 1844–45. The river current was dangerously rapid, the machinery novel to the workmen, and the winter proved to be a rigorous one. Added to these physical difficulties was the more subtle and intangible one of hostility among neighboring engineers. But "a strenuous soul hates cheap successes," and Mr. Roebling's energies were braced instead of undermined by these obstacles. With energy, patience, and a divine faith in himself, he commenced the work. Within the specified time he had built the aqueduct, comprising seven spans of one hundred and sixty-two feet each, consisting of a wooden trunk to hold water, and supported by a continuous wire cable on each side seven inches in diameter. It was opened to commerce May, 1845, scoring a brilliant victory for Mr. Roebling, being the material proof of his triumph over hostile conditions, and the strict accordance of his ideas with the great laws of civil engineering.

One such triumph secured him opportunity for further development of his ideas. The old bridge at Pittsburgh being destroyed by fire, he constructed the Monongahela suspension bridge on piers of the old one. It consisted of

eight spans one hundred and eighty feet each, supported by two four-and-a-half inch cables.

In the interim, between 1848 and 1850, he removed to Trenton, New Jersey, and constructed four suspension aqueducts on the line of the Delaware and Hudson Canal.

In 1851 Mr. Roebling's attention was called to a proposed railway suspension bridge across the Niagara River. Stephenson did not believe the suspension principle could be made practical for railway traffic, and in accordance with this idea, constructed a tubular bridge over Menai Straits, though he had to deal with spans not greater than four hundred and seventy feet. Mr. Roebling, with a clearer conception of the possibilities of the suspended span, adopted it and gave us our first railway suspension bridge with a clear span of eight hundred and twenty-five feet, supported by four wire cables ten inches in diameter. The bridge was finished in four years and opened to the public in 1855, its successful completion establishing Mr. Roebling, not only as a wise delineator of indisputable principles, but also as a true interpreter of the prophetic spirit of human progress.

In 1856 this indomitable worker commenced a suspension bridge over the Kentucky River and had completed the towers when a financial collapse put an end to the enterprise. From 1858 to 1860 he was engaged in erecting another suspension bridge at Pittsburgh. The Civil War interposing, the structure remained incomplete till 1867, when the work was resumed and carried to a successful issue.

In 1865 Mr. William C. Kingsley, giving expression to a fast-growing sentiment in the minds of the people, employed an eminent engineer to make estimates and draw plans of a bridge across East River, connecting the luxurious and pala-

tial Brooklyn with the busy marts of New York. The necessity of Mr. Kingsley's movement received emphatic recognition during the severe winter of 1866–67, when East River was gorged with ice and the snorting and toiling ferry-boats were hours making the dangerous passage between the two cities. The demands for a bridge grew vehement, and the popular excitement gave new impetus to a charter placed by leading citizens of Brooklyn before the Legislature then in session at Albany. This charter originally fixed the capital stock at five millions, with power to increase, and gave the cities of Brooklyn and New York authority to subscribe amounts to be determined by their respective Common Councils. This charter was amended so that the bridge became public property, sixty-six and two-thirds per cent. to be paid for and owned by the city of Brooklyn, and the rest by the city of New York, the actual payments by the private stockholders to be reimbursed and their title extinguished. A month after the passage of the bill, May 23d, 1867, Mr. Roebling was appointed Chief Engineer, and he made his report of surveys and estimates September 1st of the same year. These plans were fully indorsed by a board of consulting engineers convened at the request of Mr. Roebling, and also by a commission of United States engineers appointed by War Department, the latter, however, recommending an increase of five feet in the height of the bridge.

All of Mr. Roebling's previous labors had been but stepping-stones to this gigantic engineering feat with its bold and unprecedented leap of nearly two thousand feet from city to city. With what personal pride he entered upon this the crowning triumph of his illustrious career, it needs no deep insight into human nature to conjecture. New York,

the chief city of a young but mighty Republic, had called upon him to erect for her a highway of unparalleled grandeur across an arm of the sea, dividing its great heart in twain. This honor, too, was but a just recognition of his genius since he had no claim of birthright to predispose American favor in his behalf.

If, as one of the greatest of modern philosophers contends, the work is an exposition of the workman, how solid and impregnable, how grand, how stable must have been the character of him who planned the Brooklyn bridge? Those massive towers, second in grandeur only to the ancient Egyptian pyramids; that mighty arch hanging between them holding in its strong clutch a roadway for the annual passage of forty millions of people. Out of elements that thrilled, trembled, and expanded at the kiss of the sun, sensitively acknowledged the influence of far-away heavenly bodies, and recorded every gradation of temperature, he produced stability, not by the annihilation of motion, but by humoring the moods of materials, so that their variations playing into prearranged expansion chambers are insensible in the bridge itself. This stately structure, the pride of America and the admiration of the world, is but the thought of Roebling vested with its natural grandeur. But only in imagination was his heart thrilled and gladdened by this triumph of his genius. Let us hope that the unclothed thought was enough for him since implacable death forever closed his eyes to the completed vision. In the summer of 1869, while locating the position of one of his towers, a ferry-boat entered the slip and thrust together the timbers that formed his standing-place, catching his foot and relentlessly crushing it. The painful injury resulted in lockjaw, of which he died in sixteen days.

The inspirer was dead, but before a wondering and sympathetic public had time to discuss the fate of his enterprise, his son, Washington, his admirer and co-worker, came forward to prove incontestably that the mantle of the father's genius had fallen upon his illustrious son. Stepping into the exact spot where the fatal shaft had struck his father, he carried forward the great engineering battle against restless and resisting currents of wind and water till serried ranks of wires and solid phalanxes of stone were marshalled in victorious splendor upon the field.

Unacquainted with his methods, we might well wonder what unnatural race of men towed these massive towers into place and grafted them upon their rocky bed fathoms below the river level. Who built the towers themselves, or climbed their precipitous sides to a height of two hundred and seventy-six feet and with Herculean strength lifted upon their everlasting shoulders four gigantic cables like the four great strings of some mighty Æolian harp? Who spun the cables themselves, or who, tiring of their incessant diapason, pulled down the aerial chords and weighted them with a massive roadway obedient to the use of man?

Subjecting his methods to strict analysis, we are struck with their simplicity and economy. In a work requiring the same precision and exactness as an abstract mathematical problem, he has employed only direct and simple methods of producing required results. But his directness and simplicity are the directness and simplicity of genius.

The exact location of the towers being decided upon, the water-lot was marked off by a landward row of piles one hundred and seventy-two feet in length, and at each end of this row and at right angles to it, a row extending one

hundred and two feet into the river, making three sides of an oblong inclosure. Into this was towed a huge wooden box or caisson of like dimensions and with a roof twenty-two feet thick. Upon this roof, above the water, was laid the masonry forming the base of the tower. As the caisson sunk, fresh masonry was added, and excavations were made below the river bed till March 11th, 1871, at a depth of forty-five feet below the water level the caisson under the Brooklyn tower was filled with concrete and left in its final resting-place. During December, 1870, an unfortunate fire occurred in this caisson in which Mr. Roebling himself was seriously and permanently injured. Though a strange fatality seemed to pursue the head of the enterprise, Mr. Roebling would not succumb to his sufferings, but from a couch overlooking the scene of labor he continued to direct the construction of every detail.

Seven months after the completion of the foundation of the Brooklyn tower, the one on the New York side was fitted to its rocky resting-place, seventy-eight feet below high-water mark.

The towers, awful in their impenetrable massiveness, rise to the height of two hundred and seventy-six feet, tapering from a water-line circumference of three hundred and ninety-eight feet to a roof circumference of three hundred and seventy-eight feet. The second one reached completion July, 1876, and the two stood ready to bear up the great suspension cables. These cables are fifteen and three-quarter inches in diameter and contain five thousand two hundred and eighty-two parallel wires tightly clamped together and bound with a spiral coil of wire rope. The five thousand wires were first spun into strands of two hundred

and seventy-eight wires each, nineteen strands composing a cable, the odd strand for the centre, and the other eighteen forming two circles about it. The spinning of the strands was accomplished by means of a sheave traveling along an endless belt which revolved by steam-power throughout the distance from tower to tower and back over their tops to the anchorages nine hundred and thirty feet distant on either side. The wire was passed about the sheave, the belt set in motion, and the two spans or complete circuit of wire arriving at the anchorage was placed about the great iron horseshoe fixed to receive it. The sheave was then returned empty to receive a new circuit of wire and make a new journey. The spinning of the cables was begun June 11th, 1877, and the four were completed October 15th, 1878. They swoop downward in parallel and majestic curves, meeting at their central point the upward curve of the roadway, and after climbing over the tops of the towers sweep downward again to their anchorages of stone one hundred and nineteen by one hundred and thirty-two feet at their base, rising ninety feet above high-water mark, and weighing sixty thousand tons.

The cables do not rest with a vertical pressure immediately on the tops of the towers but are placed on a "cradle," a cast-iron plate in the shape of a segment of a circle, the curved side indented to admit the cable and the straight side resting on rollers that move easily with the lengthening or shortening of the cable.

The ends of the roadway pierce the towers at a height of one hundred and eighteen feet above the water level, the land spans being nine hundred and thirty feet, and the grand central span, gently swelling like the crest of a huge billow to a central height of one hundred and thirty-five feet above

mean high-water mark, being one thousand five hundred and ninety-five feet in length. The framework consists essentially of two systems of girders at right angles to each other, braced vertically, horizontally, and diagonally, so that "no conceivable cause can ever disturb its rigid fixity of position and form." Steel suspenders droop from the cables and into these are thrust the steel beams of the roadway. The bridge is divided into five parallel avenues by the six vertical lines of trussing which project upward like steel fences. The outside avenues, nearly nineteen feet wide, are devoted to vehicles, the adjacent ones to cars moved by cables connecting with a stationary engine, while the central one, fifteen and a half feet wide and elevated twelve feet above the others, is reserved for pedestrians, securing to them a vantage ground, whence with unobstructed vision they may behold an unequaled panorama of beauty and variety. Beneath is the busy river, on either side the busier cities, two mighty batteries surcharged with life, of which the bridge is the connecting wire; beyond, "villa-dotted Staten Island," New Jersey, the Palisades, Long Island, the Narrows, the bay, and last the illimitable ocean veiling its horizon in the sky.

May 24th, 1883, the bridge was formally opened to the public, having been thirteen years in construction and having cost, exclusive of land damages and incidental outlays, nine millions of dollars. With pomp and ceremony it passed from the hands of the workmen and was dedicated to its eternal labors. Consecrated by the death of the elder and the hopeless invalidity of the younger Roebling to the slow expiation of these deeds, it bears its burdens in silent and sombre patience, and will bear them till the pitying "centuries shall have rusted its filaments into nothingness."

## BESSEMER STEEL.

HENRY BESSEMER, youngest son of Anthony Bessemer, was born in 1813, at Charlton, Hertfordshire, England. His boyhood was spent in his native village and the neighboring town of Hitchin, where he received the rudiments of an ordinary education. Notwithstanding his imperfect mechanical appliances, his early years were devoted to the cultivation of his inventive faculties. His parents encouraged him in his youthful efforts.

Like many other modern inventors, he seems to have inherited the genius of the father.

Anthony Bessemer was a member of the French Academy of Sciences at the age of twenty-five. At the time of the great Revolution of 1792 he was employed in the French Mint. During these troublesome times he was arrested and held as a political prisoner for a short time, but succeeded in escaping, at the risk of his life, and fled to England. Here his talents proved a passport to success, and he was appointed to a situation in the English Mint.

By the exercise of his ingenuity and inventive faculties he acquired in his employment sufficient means to purchase a small estate in Hertfordshire, where he afterward resided.

After settling in England, he began making improvements

in microscopes and in type-founding. He engraved an entire series of type from pica to diamond. The success of these type led to the establishment of the firm of Bessemer & Catherwood.

The great improvement which Anthony Bessemer introduced into the art of type-making was not so much in the engraving as in the composition of the metal. He discovered that an alloy of copper, tin, and bismuth was the most desirable metal for type, and the working of this discovery was very successful in his hands. He kept this secret for some years, diverting attention from the real cause of success—the composition of the metal—by inviting comparison between the shape of the type which he made and those of other manufacturers. His secret, however, was finally discovered and the process patented.

One of his discoveries was a source of considerable profit to him. It is generally known that when gold articles are made by the jewelers there are various discolorations left on their surface by the process of manufacture, and in order to clean the surface they are put into a solution of alum, salt, and saltpetre, which dissolves a large quantity of the copper that is used as an alloy. Anthony Bessemer discovered that this powerful acid not only dissolved the copper, but also dissolved a quantity of the gold. He accordingly began to buy up this liquor, and, as he was the only one who possessed a knowledge of its real value, he had no difficulty in purchasing all that he desired. From the liquor thus obtained he succeeded in extracting gold in considerable quantities, which was a source of support for many years.

By some means which he kept secret (and the secret died with him) he deposited the particles of gold on the shavings

of another metal, which, being afterward melted, left the pure gold in small quantity. Thirty years afterward the electrotype process was invented, producing the same effect.

At the age of eighteen, Henry Bessemer went to London, "knowing no one," he says, "and myself unknown—a mere cipher in a vast sea of human enterprise." Here he worked as a modeler and designer with encouraging success. With a diamond point he engraved a large number of elegant and original designs on steel for patent medicine labels.

He secured plenty of work in his line and was well paid for it.

At the age of nineteen he began to mature some plans in connection with the production of stamps which he hoped would lead him on to fortune. At that time the old form of stamps were in use that had been employed since the day of Queen Anne, and as they were easily transferred from old deeds to new ones, the government lost a large amount annually by this surreptitious practice. The ordinary impressed or embossed stamps such as are now employed on bills of exchange, or impressed directly on skins of parchment, were liable to be entirely obliterated if exposed for some months to a damp atmosphere. A deed so exposed would at last appear unstamped, and would therefore become invalid. To prevent this it was the practice to gum small pieces of blue paper on the parchment, and, to render it still more secure, a strip of metal foil was passed through it, and another piece of paper, with the printed initials of the sovereign, was gummed over the loose end of the foil at the back. The stamp was then impressed on the blue paper, which, unlike parchment, is incapable of losing the impression by exposure to a damp atmosphere. Experience showed, however, that

by placing a little piece of moistened blotting-paper for a few hours over the paper the gum became so softened that the two pieces of paper and the slip of foil could be easily removed from an old deed and then used for a new one. In this way one stamp could be used a second and a third time, thus depriving the public revenue of thousands of pounds every year.

Our young inventor at once set to work to devise a stamp that could not be used twice. His first discovery was a mode by which he could have reproduced easily and cheaply thousands of stamps of any pattern. "The facility," he says, "with which I could make a permanent die from a thin paper original, capable of producing a thousand copies, would have opened a wide door for successful frauds if my process had been known to unscrupulous persons, for there is not a government stamp or a paper seal of a corporate body that every common office clerk could not forge in a few minutes at the office of his employer or at his own home. The production of such a die from a common paper stamp is a work of only ten minutes, the materials cost less than one penny, no sort of technical skill is necessary, and a common copying press or a letter-stamp yields most successful copies."

To this day a successful forger has to employ a skillful die-sinker to make a good imitation in steel of the document he wishes to forge, but if such a method as that discovered and described by Sir Henry Bessemer were known, what a prospect it would open up! Appalled at the effect which the communication of such a process would have had upon the business of the Stamp Office, he carefully kept the knowledge of it to himself, and to this day it remains a secret. More than ever impressed with the necessity for an improved form of

stamp, and conscious of his own capability to produce it, he labored for some months to accomplish his object, feeling sure that, if successful, he would be amply rewarded by the government. To insure the secrecy of his experiments, he worked at them during the night, after his ordinary business of the day was over. He succeeded at last in making a stamp which obviated the great objection to the then existing form, inasmuch as it would be impossible to transfer it from one deed to another, to obliterate it by moisture, or to take an impression from it capable of producing a duplicate.

Flushed with success and confident of the reward of his labors, he waited upon Sir Charles Persley, at Somerset House, and showed him by numerous proofs how easily all the then existing stamps could be forged, and how his new invention prevented forgery. Sir Charles, who was much astonished at the disclosure of imperfections in the one and highly pleased with the other, asked the inventor to work out more perfectly the principle of the new stamping invention. Accordingly, Sir Henry devoted several weeks to perfecting his stamp, with which the Stamp Office authorities were well pleased. The design, as described by the inventor, was circular, about two and a half inches in diameter, and consisted of a garter, with a motto in capital letters, surmounted by a crown. Within the garter was a shield with the words, "Five Pounds." The space between the shield and the garter was filled with network in imitation of lace. The die was executed in steel, which pierced the parchment with more than four hundred holes, and these holes formed the stamp. Such a stamp removed all the objections to the old one. So pleased was Sir Charles with it that he recommended it to Lord Althorp, and it was soon

adopted by the Stamp Office. At the same time the inventor was asked whether he would be satisfied with the position of superintendent of stamps, with five or six hundred pounds per annum as compensation for his invention, instead of a sum of money from the treasury. This appointment he gladly agreed to accept, for, being engaged to be married at the time, he thought his future position in life was settled. Shortly afterward he called on the young lady to whom he was engaged, and communicated the glad tidings of bright prospects, at the same time showing her the design of his new stamp. On explaining to her that its chief virtue was in prohibiting the new stamps thus produced from being fraudulently used twice or thrice, she instantly suggested that a date put upon the stamp might add additional security to its legal use. This idea was new to him, and, impressed with its practical character, he at once conceived a plan for the insertion of movable dates in the die of his stamp. Having worked out the details of a stamp with movable dates, he saw that it was more simple and more easily worked than his elaborate die for perforating stamps; but he also saw that if he disclosed his latest invention it might interfere with his settled prospects in connection with the carrying out of his first one. It was not without regret, too, that he saw the results of months of toil and the experiments of many lonely nights superseded, but his conviction of the superiority of his latest design was so strong, and his confidence in that of the government so unsuspecting that he boldly placed the whole matter before Sir Charles Persley. Of course the new design was preferred, as with it all the old dies, old presses, and old workmen could be employed.

Among the other advantages which it presented to the government was the fact that no superintendent of stamps would now be necessary, a recommendation which the perforating process did not possess. The Stamp Office therefore abandoned Sir Henry's first invention in favor of his latest one, which is still in use. At the same time the government abandoned the office of superintendent of stamps it abandoned the ingenious inventor.

The revenue from stamps grew enormously. The Stamp Office reaped a benefit which it is scarcely possible to estimate, while the inventor did not receive a farthing.

"Success or failure in first efforts often mold the course of after life; adversity often acts as a stimulant." Fortunately, this was the case with Sir Henry Bessemer. While smarting from the injustice of the government, he was encouraged by the mechanical success of the invention that they had appropriated. He therefore continued to work out new inventions, but took care in future to turn them to more profitable account, and to protect them from piracy.

His attention was next directed to the difficulty of obtaining good patterns of figured Utrecht velvet, and he soon invented a machine that overcame this difficulty. Some of the velvet it produced was used in furnishing the state apartments at Windsor Castle, and several of these designs are still in use.

The next matter that seriously engaged his attention was the process of type-casting, improvements in which formed the subject of his first patent.

His machine, which was patented March 8th, 1838, produced the most accurate type ever cast up to that date.

Some years after, he constructed what was known as

"Young's Composing Machine," with which *The Family Herald* was "composed" by a young lady, who with it could set from six to seven thousand type per hour for ten consecutive hours, but ultimately the great opposition of the compositors led to its abandonment.

"Shortly after he had taken out his first patent his attention was accidentally turned to the manufacture of bronze powder, which is used in gold work, japanning, gold printing, and similar operations. While engaged in ornamenting a vignette in his sister's album, he had to purchase a small quantity of this bronze, and was struck with the great difference between the price of the raw material and that of the manufactured article. He concluded that the difference was caused by the process of manufacture, and made inquiries with the view of learning the nature of the process. He found that this manufacture was hardly known in England. The article was supplied from Germany. He did not succeed, therefore, in finding any one who could tell him how it was produced. Under these circumstances, he determined to try to make it himself, and worked at it for two years before success crowned his efforts."

"Knowing very little of the patent law, and considering it so insecure that the safest way was to keep it to himself, he determined to work his process of bronze-making in strict secrecy. He first put up a small apparatus with his own hands, and worked it entirely by himself. He then sent out a traveler with samples of the article, for which he received enough orders to feel assured of success. He then communicated his plans to a friend, who agreed to put ten thousand pounds into the business as a silent partner. The entire working of the concern was left in the hands of Sir Henry.

To insure secrecy, he made plans of all the machinery required, and then divided them into sections. He next sent these sectional drawings to different engineering works, in order to get his machinery made piecemeal in different parts of England. This done, he collected the various pieces and fitted them up himself, a work that occupied him several months. Finding everything at last in perfect working order, he engaged assistants in whom he had confidence, and paid them very high wages, on condition that they kept everything in the strictest secrecy.

"Bronze powder was now produced in large quantities by means of five self-acting machines, which were capable of producing as much daily as sixty skilled workmen could do by the old hand system.

"This machinery has been in constant use for over forty years without having been either patented or pirated.

"Three out of the five assistants have died, and in 1871 Sir Henry rewarded the faithfulness of his surviving assistants by handing over to them the business and factory."

At the great exhibition of 1857 he exhibited several different kinds of machines which were considered ingenious combinations of simplicity and power. One was a pump for land and sewer drainage capable of discharging twenty tons of water per minute, and of draining in one hour an acre of land one foot deep in water.

"A novel machine for grinding and polishing plate-glass was much admired. In it a slate table on which the plate-glass was laid had a series of grooves and, by extracting the air from these grooves by means of an air pump a vacuum was produced so that the pressure of the atmosphere on the upper side of the glass held it firmly to the table while it was

being ground and polished. By turning a cock which admitted the air again the plate of glass could be instantly removed. The plan then in use for holding down sheets of glass was to imbed them in plaster of Paris—an operation which had to be performed four times for each plate, and in which forty tons of plaster per week were consumed in some establishments. This was considered one of the most valuable apparatus among the mechanical appliances exhibited."

In 1853 when the public mind was much exercised by the prospect of the impending war with Russia, Sir Henry Bessemer enthusiastically devoted his attention to the improvement of the projectiles and ordnance then in use.

He soon constructed elongated projectiles to which a rotary motion was imparted during their passage through the air without the aid of rifled grooves which still continue to be made in our ordnance and without any deviation from the true cylindrical bore of the gun. To effect this he made small passages lengthwise through the projectiles and open at the end nearest the breech of the gun. Through these passages a part of the exploded powder found its way, and being emitted from the opposite sides of the projectile the reactive force of the exploded gunpowder produced the rotary motion required. Among other peculiarities of this gun was an enlarged powder chamber—an improvement that was made the subject of experiment by other inventors a quarter of a century afterward—and he consequently insisted on increasing the strength of his gun and the metal near the breech. To prevent inconvenience from this increased weight he constructed his gun in parts which were bolted together.

"By this mode of forming guns I am enabled," he said, "to use iron and steel and thus form a gun of great strength, the parts of which are of comparatively little weight, while it also admits of the various parts being made of the metals most suitable to resist the peculiar strain and wear to which they are severely subjected when in use."

Seeing that the English Government had no good artillery suitable for firing elongated projectiles and considering the system of rifled grooves as dangerous, he made a series of experiments with six-pounder shots with which he got what he considered more than ample rotation in a smooth-bore gun. He then submitted his plan to the Government authorities at Woolwich, but it was simply pooh-poohed. They never even tried it.

Shortly after this, while Sir Henry was on a visit to Paris with Lord John Hay, he attended a dinner given to distinguished French officers before their departure for the Crimea. At that dinner Sir Henry met Prince Napoleon, to whom he took occasion to mention his plan of firing elongated projectiles. So favorably was the Prince impressed that he asked Sir Henry to explain it to the Emperor, and with this view arranged an interview. The Emperor was so pleased that he invited Sir Henry to continue his experiments at Vincennes. Other business recalling Sir Henry to London, he asked the Emperor's permission to make his experiments in London and to bring the projectiles to Paris for trial. His Majesty not only consented, but said, "In this case you will be put to some expense, but I will have that seen to." Sir Henry returned to London, and in a few days afterward received an autograph note from the Emperor, authorizing him to draw on "Baring Brothers," of London, for the cost of

manufacturing projectiles, but leaving him to fill in any amount.

A good many projectiles were made and sent to Vincennes for trial. Two days before Christmas, when the ground was covered with six inches of snow, several thirty-pounder projectiles were fired through ten boarded targets standing in a straight line, each target being about one hundred yards distant from the other. In this way it was shown by the circular holes made in these targets that the plan of the inventor imparted sufficient rotation to his elongated projectiles which generally passed through seven of the targets. A mechanical device was also affixed to the mouth of the gun to show the precise amount of rotation by marking the projectiles, and several shots recovered from the snow indicated from one and a half to two and a quarter rotations in passing through the length of the gun, being a greater twist than that produced by the ordinary system of rifling.

These promising results were considered satisfactory by the French authorities, and they fully justified the anticipations of their designer, but just at the moment when success appeared to be on the point of crowning his labors an incident occurred that changed the whole course of his future life, that materially affected the industrial progress of the world, and afforded another illustration of the saying, "What great events from little causes spring."

It is but rarely that we can lay hold with certainty of the thread by which genius has been guided in its first discoveries. This desideratum, however, is not wanting in the case of the great invention that revolutionized the steel trade. When Sir Henry Bessemer had shown to the French military authorities the result of his system of firing elongated pro-

jectiles from a light cast-iron smooth-bore gun, Commander Minie, who superintended the trials, remarked to him, "The shots rotate properly, but if you cannot get stronger metal for your guns such heavy projectiles will be of little use." It was this observation that first led Sir Henry to think of the possibility of improving the manufacture of iron. It suggested to him a new field of invention, and he instantly determined

"To brave the perils that surely environ
The man who dabbles in cast-iron."

In reporting the results of his artillery experiments to the Emperor he intimated his intention of extending his researches to the kind of metal most suitable for artillery purposes. Napoleon gave every encouragement to this new project, and requested that the results might be communicated to him.

"When Sir Henry Bessemer determined to make improvements in the manufacture of iron and steel he had not the least idea of how he was going to do it. Both the rudiments and the history of metallurgy were unknown to him, and, at first sight no subject could appear less inviting. The process then in use for making steel had been practiced for nearly a century without any improvement, and the history of its invention was by no means encouraging.

"An honest and skillful clockmaker named Huntsman who lived at Doncaster in 1738 was so annoyed at the defective nature of the watch springs then used in his trade that he began to make experiments with the view of producing a better quality of steel. Little is known of his experiments, for he kept them strictly secret. After long-continued efforts and many failures he did succeed in his aim, and the process

which he then invented was the only one in use for the next hundred years. Until then the finest steel was made by the Hindoos, and the price of it, previous to Huntsman's invention, was ten thousand pounds a ton.

"Huntsman kept his valuable invention a secret for many years. The Sheffield manufacturers multiplied their efforts to fathom the secret which had been so well kept.

"In the dismal darkness and bitter cold of a winter's night a beggar knocked at the entrance to Huntsman's works. The snow was falling heavily and all outside was gloom and darkness. The shivering beggar asked for shelter. The workmen instantly assented and assigned him a warm corner of the building where he soon fell asleep. But it was a cat's sleep, for, while the unsuspecting workmen proceeded with their work, the sleeping beggar 'eyed' them and, as the process lasted several hours he continued his feigned sleep. It afterward transpired that the sleeping beggar was an iron-founder of Sheffield, and the success of his stratagem was attested by the erection of a steel works similar to Huntsman's.

"It was this system of manufacture that was employed when Sir Henry Bessemer's attention was directed to metallurgy.

"The iron then used for making steel was mostly imported from Sweden, Russia, and Spain.

"With a view of acquiring practical knowledge of the system then in use for converting ore into iron, he visited the iron-working districts of the north, and upon his return to London arranged for the use of a factory and began his experiments.

"After twelve months time and many costly experiments he

succeeded in producing an improved quality of cast-iron, almost as white as steel, and tougher and stronger than the best cast-iron then used. Of this metal he cast a small model gun which he presented to the Emperor of France. The comments of the great French leader encouraged Sir Henry to continue his experiments until he had extended their scope from the production of refined iron to that of steel."

The labor and anxiety entailed by these experiments brought on a short but severe illness, and while he was lying in bed pondering on the prospects of succeeding in another experiment with the pipes and pots, it occurred to him that difficulty might be got over by introducing air into a large vessel from below into the molten mass within.

Though he entertained grave doubts as to the practicability of carrying out this idea, he determined to put it to a working test, and, on recovering health, immediately began to design apparatus for this purpose. He constructed a circular vessel, measuring three feet in diameter and five feet in height, and capable of holding seven hundred-weight of iron. He next ordered a small powerful air-engine and a quantity of crude iron to be put down on the premises. The name of these premises was Baxter House, formerly the residence of old Richard Baxter, and the simple experiment here described has made that house forever famous.

The primitive apparatus being ready, the engine was made to force streams of air under high pressure, through the bottom of the vessel, which was lined with fire-clay, and the stoker was told to pour the metal, when it was sufficiently melted, in at the top of it. A cast-iron plate—one of those lids which commonly cover the coal-holes in the pavement—

was hung over the converter, and all being got ready, the stoker in some bewilderment poured in the metal. Instantly out came a volcanic eruption of such dazzling corruscations as had never been seen before. The dangling pot-lid dissolved in the gleaming volume of flame, and the chain by which it hung grew red and then white as the various stages of the process were unfolded to the gaze of the wondering spectators. The air-cock, to regulate the blast, was beside the converting vessel, and no one dared go near it, much less to deliberately shut it. In this dilemma, however, they were soon delivered, by finding that the process of decarburization or combustion had expended all its fury, and, most wonderful of all, the result was steel. The new metal was tried. Its quality was good. The problem was solved. The inventor was elated.

The result of this first experiment showed that the highest temperature ever known in the arts could be produced by the simple introduction of atmospheric air into cast-iron. After many experiments had been made and large sums of money expended, Sir Henry became anxious for other opinion on the process, accordingly he invited Mr. George Rennie to inspect the work. On seeing the result of a "blow" in the converter, Mr. Rennie said: "This must not be hid under a bushel. The British Association meets next week; if you have patented your invention, draw up an account of it in a paper and have it read."

Acting under this suggestion, Sir Henry wrote a description of his new invention, entitling it, "The Manufacture of Malleable Iron and Steel without Fuel." This was the first public announcement of the Bessemer process, made August 11th, 1856.

The new process having been successfully tested by various iron manufacturers throughout the kingdom, large sums of money, varying from ten thousand to one hundred thousand pounds, were offered for the patent, all of which Sir Henry declined. He desired an annual income from his invention, and with that plan in view arranged to receive so much per year from each firm using his process, the amount to be proportionate to the quantity of steel manufactured.

The Dowlais Iron Company were the first to take a license, and it was arranged that Sir Henry should advise them as to the details of working the process.

The manager of the works said: "We have seventeen furnaces in blast, and I will tell you the burden of each of them, you can select your furnace, and if it is possible to put up your apparatus before it, we will do so." Sir Henry replied: "It does not matter where you put up my apparatus, it will work any kind of iron." At that time the furnace where they put up the converter was making iron for common rails. This iron, in its fluid state, was then run direct from the furnace into the converter, where it blazed, sparkled, bubbled, and showed all the beautiful phenomena of the process. The whole operation looked very satisfactory; but when they came to work the metal produced, they were surprised to find it utterly useless for any purpose. This appeared inexplicable, so the experiments were repeated, but the success of the first rude experiment was never equaled, and Sir Henry left Dowlais with serious apprehensions as to the success of his invention.

The bright prospect which the first announcement of the process raised was now overcast, and was eventually followed by a general gloom. An invention which at first was received

with a shout of triumph, was two months afterward declared to be impracticable.

Then followed months of incessant thought and labor, and of experiments to overcome the new difficulty.

At the expiration of about three years Sir Henry was fully satisfied that he had overcome the trouble attending the continued success of his new process.

His next task was to convince the public that an invention which for two or three years had been entombed in the oblivion of demonstrated failure was now a complete success. To do this required both skill and courage. The incredulity with which great discoveries have almost invariably been received by the public, when viewed through the perspective of subsequent events, forms one of the most remarkable chapters of human history. In every age there are people who think themselves interested in maintaining the existing state of things. Sir Henry Bessemer knew this only too well. Having succeeded in producing steel by his process, he wished to demonstrate its properties by actual use. With this in view he asked his friend, Mr. Galloway, of Manchester, to distribute the new metal among his workmen when they asked for steel to make tools with, but not to let them know that it was in any way different from what they had been accustomed to use. This was done, and in six weeks Sir Henry returned to Manchester to hear the result. "What do the workmen say about the new steel?" inquired the anxious inventor. "They have said nothing at all about it," replied Mr. Galloway. "Nothing at all. Oh! then it will be all right; that they have no fault to find with it is the best report of any." Sir Henry went among the workmen, and asked what they thought of the steel they had last used. "There's no difference between it and other

steel—it's no better than we always get." Such a recommendation was sufficient. The steel formerly cost sixty pounds per ton. This new steel cost six or eight pounds a ton.

After many difficulties the new process began to make progress. Its superiority in respect of rapidity and cheapness over the old process was spreading consternation in the steel trade. One manufacturer after another applied for license to use it. Others endeavored to secure its advantages by other means.

One day Sir Henry found a London gentleman occupied in his office with a packet of papers a foot high, getting out all the cases he could against him for repealing by *scire facias* the whole of his patents. He was employed by a company of iron-masters to do so, and said afterward: "When I had gone through the whole of Sir Henry patents and about seventy others which they said anticipated his, I found that they had not a leg to stand upon, and I advised them to apply to him for a license."

Sir Henry, in giving an account of the process and its results to the Institution of Mechanical Engineers in August, 1861, said:

"For the practical engineer enough has already been said to show how important is the application of cast-iron to constructive purposes, and how this valuable material may be both cast and forged with such facility as to produce by its superior durability and extreme lightness an economy in its use, as compared with iron. The construction of cast-steel girders and bridges, of marine engine-shafts, cranks, screws, propellers, anchors, and railway wheels are all deserving of careful attention. The manufacturer of cast-steel has only to produce the various qualities of steel required for constructive

purposes to insure its rapid introduction; for as certainly as the age of iron superseded that of bronze, so will the age of steel succeed that of iron."

Beside taking out more than one hundred patents Sir Henry Bessemer has invented many wonderful things which he has never patented, such as government stamps of paper, patterns for figured velvet, a telescope and so on through a long list of useful and ornamental articles, by which the versatility of his genius was clearly exemplified and much admired.

Honor and distinction are his inalienable rights. A multiplicity of medals, titles, and degrees from every quarter of the globe attest the great esteem of his fellow-men.

The Bessemer telescope stands on the Bessemer estate, which is some thirty or forty acres in extent, and is on the slope of a hill looking toward the Crystal Palace.

The same genius that stamps the highest type of mechanical and practical science is shown in the artistic arrangement of the grounds surrounding and adjacent to Sir Henry's beautiful residence. What nature has begun art has extended. No more beautiful landscape can be imagined than the reality of Bessemer estate on Denmark Hill, near London.

BENJAMIN WEST.

## PAINTING.

ONE hundred and fifty years ago, Springfield, a Quaker village, slumbered peacefully among the hills of Southern Pennsylvania. Life flowed there in a sluggish stream. The morning stillness was unbroken by the rumble of loaded trains or the shrill whistle of imperious steam. The serenity of evening was not startled by the click of the telegraph, with its swift messages of revolution and rebellion, of disaster and death. To the east, softly undulating hills shut out the horizon. To the west stretched an unbroken forest of a thousand acres, in which roamed wild and ferocious beasts and the untamed and half-naked savage. The sturdy musket was the sure accompaniment of all whom inclination or necessity impelled into the heart of this sombre wood. Simple, quiet, stagnant the village lay on the borders of this wood like some silent inland lake dreaming of its own unruffled beauty. The primitive and simple lives of the Quakers, and their slow, plodding habits of methodical industry was the peaceful accompaniment of the scene. Each man with grave humility performed his task, storing yearly "his little dues of wine and wheat and oil."

"His best companions innocence and health,
And his best riches ignorance of wealth."

In this rude and simple village genius was pleased to cradle her offspring. She gave him the unbroken solitude of the forest, the placid and peaceful faces of the Quakers and the sombre and sunless background of their lives to impress their solemn pictures on his mind. She called him from among these staid and solemn children, and said, "Go interpret to the human, the divine." How he answered her call, and struggled to fulfill his trust, let those tell who have stood before the canvases of "Christ Rejected" and "Death on a Pale Horse." The author of these paintings, Benjamin West, the favorite of fortune and the petted *protégé* of nobility, made the first plaintive cry that betokened his existence in this primitive Quaker village of Springfield.

His English forefathers, the Wests of Long Crendon, embracing among their number Col. James West, the friend of John Hampden, traced their lineage back to Lord Delaware. The descendants of this war-loving nobleman forever sealed the covenant of peace, in 1667, by embracing the tenets of the Quakers. America, with its broad, unoccupied prairies, its soil yielding abundant harvests, its favored climate, and the varied character of its products was drawing a steady stream of emigration from the Old World to the New. Borne on its tide, these Wests of Crendon found a resting-place in Springfield, and there set up their household gods. John West, one of the many offshoots of this parent stem, after a quick courtship, was married to Sarah Pearson, of the Society of Friends, whose grandfather had been the trusted companion of the honored Penn. The sole dowry which, we are told, came to her husband through this marriage was a negro slave, a faithful and humble servant. John West, however, in his trade with the Barbadoes, having been an

involuntary witness to the cruelties that were practiced upon these degraded and unhappy wretches, determined to set at liberty his bondsman. Struck by the generosity of this act, involving as it did so great a personal sacrifice on the part of West, the Quakers at once adopted it as a tenet of their faith "that no person could remain a member of their community who held a human creature in slavery." So this one good act received an everlasting memorial.

Whether or not, by this noble act, John West secured to himself the perpetual sunshine of Divine favor, we cannot tell; but it is certain he found himself heir to those blessings that the "sweet singer of Israel" tells us belong to the righteous. Ten olive plants bloomed about his table. On the eve of the birth of the tenth, his wife attended a meeting in the fields and listened to a sermon so full of frightful pictures, and so penetrated with wails of despair that she became dangerously ill from mental excitement and agitation. The ebbing tide of life only began to turn and flow slowly back to the poor, terror-stricken woman when her baby was placed in her arms. This baby was Benjamin, born October 10th, 1738. The preacher, who had sent such arrows of danger, mingled with his arrows of conviction, on hearing of the event, at one predicted for the child, "born under such peculiar circumstances," a wonderful career. How far this prophecy, believed in by the credulous Quaker, influenced him in after years, it is difficult to compute. At any rate, he and his wife tended this latest olive plant during the years of childhood with loving and expectant care, looking for the blooms and fruit propitious augury had foretold. After seven years, they found the first tender swelling of the bud of genius that afterward flowered and attained its full fruition

when those loving and gentle hands had been crossed in everlasting repose.

At seven, that happiest year of happy childhood, little Benjamin was playing in the garden, where his mother and eldest sister were gathering flowers. This sister had been some time married, and was enamored of the sweets of a little human flower that had sprung up at her side. This drowsy little flower, having shut its eyes in sleep, Benjamin was sent to watch by its cradle during the absence of maternal care. Guarding the sleep of infancy, his eyes lingered with tender admiration upon this young thing, so fresh from the hands of God, its softly traced contour, its cheeks of mingled rose and pearl, its curving, crimson lips, its brow as white as innocence itself. A smile, the reflex of some happy dream, dimpled about the baby's mouth. Infatuated, inspired, this childish watcher caught the evanescent beauty of a baby's smile and placed it beyond the power of escape. On the return of mother and sister they found him absorbed in the contemplation of the baby's picture done in red and black ink on common paper. The swift intuition of mother love divined in this the foreshadowings of something yet to be. The father, for whose inspection the little picture was carefully preserved, affirmed that this was but the unfoldings of the prophecies at his birth.

Later on his drawings of birds and fruits and flowers won admiration from the tribes of Cherokee Indians about him, and they taught him the composition and preparation of the red and yellow dies with which they stained their arrows. These, with the indigo of domestic use, supplied him with the three primary colors. Here were the colors and there the paper, and designs and impressions were in his mind, but the

source of mystery to him now was the mode of application of the colors to the paper. Some neighbor had it from tradition that painters used brushes made of camel's hair. Camels, he was told, were to be found in the far East, and here he was on the limits of the known West. His ingenuity had recourse to the cat, and he secretly divested poor Tabby of almost all of her fur. This nudity of the cat was attributed to disease by the other members of the family till Benjamin tremblingly confessed his crime—a crime most readily condoned when its motive was also confessed.

A Mr. Pennington, a relative of the family, hearing of this escapade, made this youthful defrauder of the fur of cats a present of a box of paints and six engravings by Grevling. To gloat on his unexpected treasures and to preserve them from the touch of vandal hands Benjamin stored his pictures and paints in the garret. He was now nearly nine and attended the village school, but so strong was the enchantment of this new and divine love that thoughts of duty were forgotten. Secretly and incessantly he labored for days, shutting himself up in the garret, peopled to his excited fancy with such exquisite possibilities. The school-master complained to the mother of the aberrations of her boy. Climbing to the garret, on thoughts of punishment intent, she beheld her son in silent contemplation of his work. He had made, not a copy of the several engravings, but by grouping and blending had wrought a new design and told a new story. This picture hangs by the side of "Christ Rejected," on the walls of the Royal Academy, and years afterward, when West was a famous painter, he acknowledged "there were touches of art in it that he had never been able to surpass."

When nine years old Benjamin went with his relative and patron, Pennington, to Philadelphia, and made a picture from nature of the banks and winding water of the river. Mr. Williams, an artist in the neighborhood, was struck by the quality of such work from childish hands and invited Benjamin to his studio. The effect upon his emotional nature was instantaneous and he burst into tears.

"What books do you read?" asked Mr. Williams. "You ought to read the lives of great men."

"I read the Bible," answered the young Quaker. "I know the lives of Adam and Joseph, of Moses, of David, of Solomon and the Apostles." In such sublime words did he show the clear conceptions of his faith. He returned from this trip with the settled determination to be an artist.

At school Benjamin did not apply himself to his books with that ardor and method which the acquisition of knowledge requires. We are told that he managed to pass in all his studies except arithmetic. The science of numbers was too absolute to accept any compromise, and West had to resort to ingenuity to evade punishment. This he did by securing the services of some more plodding intellect, and in return he drew for the boy who worked his sums pictures of birds and leaves.

One half-holiday West was invited by a school-fellow to take a ride with him. The inviter was in the saddle, and there being but one horse, the invited must needs ride behind. "I do not ride behind any one," was West's reply to the invitation. The good-natured school-boy instantly relinquished the seat of honor to this spoiled child, and the two proceeded in good spirits.

"This is my last ride for a long time," said the owner of the horse, "to-morrow I am to be apprenticed to a tailor."

"Surely you will never be a tailor," answered Benjamin, with disgust. "I intend to be a painter."

"A painter! What sort of a trade is that? I never heard of it before," said the embryo tailor.

"A painter is the companion of kings and emperors," and with this he leaped from the horse, adding, "I will not ride with one willing to be a tailor." This is the first indication we have that the spoiling and petting was beginning to affect the simplicity of the gifted child. True genius chooses irrevocably its calling; if it brings the companionship of kings and emperors, it is but a happy and incidental thing; if it secures but the lonely hermitage of the garret—ah! Well, it is fate, it is unavoidable and invincible!

A Mr. Flower, a Justice of Peace in the adjoining village of Chester, hearing of the talented boy, invited him to his house. He had secured the services of an English lady as governess for his own children. This accomplished woman was so pleased with the bright and attractive boy that she read to him from the original Greek and Latin stories of by-gone poets, philosophers, painters, and historians. To one who had never before heard of Greece or Rome this was a new and sparkling fountain, and he drank deep draughts with that intensity of pleasure that comes only from long-continued thirst.

From Chester he went to Lancaster at the request of a Mr. Ross to paint the portrait of his young and beautiful wife. This gave him considerable notoriety among the citizens of Lancaster. A gunsmith who, while he worked his forge, had also cultivated the classics, proposed to the young

artist to take the death of Socrates as a subject. West had just been listening to the story of the life of Socrates and his heroic death as related by the English governess, and his imagination quickly acted on the hint of the gunsmith. The figure of Socrates he completed to his satisfaction, but when he came to the slave handing the poison—"The slave ought, I think, to be naked," going, in his dilemma, to his friend of the forge, "and I have always painted men clothed." The gunsmith returned to his forge and presently brought out one of his workmen, half-nude and splendidly formed, saying "There is your model." West introduced him with his bare limbs into the picture. So early as this did he show that his conceptions of art were the purest.

West had now been roaming about so long indulging his one passion that at the age of fifteen we find him with barely the rudiments of an education. Dr. Smith, whose kindly interest in the boy induced him to undertake the part of tutor, with mistaken judgment allowed Benjamin to shirk hard and disagreeable study and to skim through the classics, fastening his attention only to those incidents likely to inflame his imagination. What he needed most was severe and methodical study, but this his indulgent tutor and more indulgent parents did not realize.

There was now a serious question to be discussed and answered. One of the peculiar articles of faith among the Quakers was the condemnation of the art of painting as being an agency "employed to embellish life, to preserve voluptuous images, and add to the sensual gratifications of man." The Wests were Quakers, and conformed in all things as did the others to the strictures of their sect. The question as to whether Benjamin might follow the beckonings of his genius

was submitted to the Society for their wise consideration. Benjamin was ruled out while these deliberations of such deep moment to him were held. The spirit of inspiration came first to a Mr. Williamson. "God has bestowed on this youth a genius for art," he said, "shall we question His wisdom? I see the Divine hand in this; we shall do well to sanction the art, and encourage the youth." Like a wind that bends every golden wheat-head down in assent to its whispered love-tale, the same spirit moves over the hearts of these Friends, and every head bowed in grave consent to the words that had been spoken. Benjamin was called in, and Mr. Williamson continued his address: "We have classed painting among vain and ornamental things and excluded it from among us. But this is not the principle, but the misemployment of painting. In wise and pure hands it rises in the scale of moral excellence, and displays a loftiness of sentiment worthy the contemplation of Christians. God hath endowed this youth with rich gifts. May it be demonstrated in his life and works that the gifts of God have not been bestowed in vain, nor the motives of the beneficent inspiration which induces us to suspend the strict operation of our tenets prove barren of religious or moral effect." The voice ceased. One man arose and laid his hand in silent benediction upon West's head; another followed, till all the men had blessed him, and then the women consecrated him, each by a kiss, to his work. West now considered himself dedicated to Art, to uphold its sanctity and purity.

Shortly after this young West, aged about eighteen, released from the strict pressure of the rules of the Society, and animated by some impulse bequeathed by his warlike ancestors, enlisted as a soldier and joined an expedition that went

in search of the relics of General Braddock's army. With these was Major Sir Peter Halket, whose deep personal interest in the expedition centered in the discovery of the remains of his father and brother. Many months had elapsed since the battle, but the Indian guide assured Sir Peter he had seen an elderly officer drop dead, and a young subaltern who ran to his assistance, fall mortally wounded across his body. After a long march they came at last upon the "valley of death." The Indian pointed out the exact spot of the awful tragedy that befell father and son, and when the newly-fallen leaves were thrust away, there they lay, one skeleton above the other. Long afterward, West conceived the idea of embodying this scene in a picture, containing as it did all the elements of weird and tragic grandeur. The ghastly relics of what was once noble and brave, the stoical faces of the Indians and the sympathetic ones of the whites grouped about, the horror that struck young Halket senseless—this in its sombre setting of the gloomy wood, had powerfully moved the emotional nature of young West. Had he followed his own inclination and painted this instead of pandering to the tastes of others, it would doubtless have been one of his best efforts and a worthy companion piece to the "Death of Wolfe," since we can always depict best that which we have personally and strongly felt.

Tragedy was awaiting him elsewhere, the tragedy of death in his humble Quaker home. A messenger brought him news that his mother was dangerously ill, and having hastened home, her sweet spirit smiled upon her favorite son, then she could not speak, and was gone. He soon abandoned the home thus deprived of its presiding genius, and established himself in Philadelphia as a portrait-painter. His

DEATH OF WOLFE. From the Painting by Benj. West.

prices he kept at a small figure, two and a half guineas a head, and this money he carefully saved. From Philadelphia he went to New York, doubled his price and hoarded as carefully as before, hoping to acquire by industry and economy a sum sufficient to take him abroad in the prosecution of his art-studies.

From this point in his story West stepped into the full sunshine of fortune. A letter from Philadelphia informed him that a cargo of corn and flour was to be sent from New York to Italy, and that the expedition had been placed in charge of one of the Allens of Philadelphia. This gentleman, influenced by Dr. Smith, West's former tutor, offered to the young art student a passage to Leghorn. From Leghorn to Rome was but a short distance and Rome was the home of art. So elated was West by this news that he was unable to bear the happy secret alone, and so confided it to a Mr. Kelly, who was at that time sitting to West for a portrait. This gentleman congratulated him on his good fortune, paid for the finished portrait, and gave him a letter to hand to his agents in Philadelphia. West on arriving in Philadelphia and presenting the letter was told it contained an order for fifty guineas from the generous Kelly, "to aid him in prosecuting his art studies!" He had never known the lack of money in his earliest days, and his star of fortune was still ascending.

He was now twenty-two, in good health, with plenty of money, and on the eve of embarking for Italy, the goal of his fondest dreams. But one cloud appeared on his horizon, and we cannot well believe this cloud overshadowed him to any painful extent, since his was a cold, unimpassioned nature incapable of intense suffering. Miss Elizabeth Shewell, a beautiful young girl of Philadelphia, had become enchanted with

the young artist, and in return for her tender and romantic love, he had given her a sort of passionless regard, which she was forced to accept as the best of which he was capable. A formal betrothal had taken place. The brother of Miss Shewell had selected another of her suitors for her acceptance, whom she peremptorily refused. He would not permit West to come to the house, and so much was he afraid some elopement scheme would be developed, he placed Miss Shewell in close confinement in her own room under lock and key; nor did he relax his vigilance till West had set sail for the Old World. This he did, leaving his sweetheart in imprisonment.

West carried his good fortunes with him into the "city of dead empires." He presented his letters of introduction to some of the leading men, and he soon became a subject of interest and curiosity among native artists. All desired to see this young barbarian from the wilds of the mystical land under the setting sun. Lord Grantham, the first to bestow his patronage, invited him to dinner and introduced him at an evening assembly of artists and people of distinction in society. The Italians crowded about him with ill-concealed curiosity, but the grave simplicity of the manners of the young Quaker left them nothing at which to cavil. These Romans who had been nurtured in the lap of art, for whom the Apollo had posed his graceful form, and the Venus displayed her charms, and to whom the works of Raphael were more familiar than common wood-cuts were to West, turned out *en masse* to see him, dazzled by his first view of these immortal and inimitable creations. Thirty equipages, filled with Rome's choicest leaders in society and art, formed the escort of this young and unknown American. The Apollo

was concealed in a cabinet, and when the doors were thrown open—"My God! A young Mohawk warrior!" exclaimed West. Indignant surprise spread from face to face. What! had this young savage traveled all the way to Rome to find in this grand statue but a copy of a fellow-savage? West, immediately divining the light in which he stood, hastened not only to justify his criticism but to convert it into the highest encomium by describing the freedom and elasticity of the movements of an Indian warrior, his length of limb and breadth of chest, his perfect symmetry, and statuesque grace when in repose.

Mengs was the authority on art at that time in Rome. West knew his own inability to produce an accurate and finished sketch, and was ashamed to exhibit his inferior drawings in this company of critics. But to establish his claim to be considered at least an humble member of the brotherhood, he persuaded Lord Grantham to sit to him for a portrait. The scheme was kept a profound secret, and the finished picture was placed in the gallery of Crespigni, where it was sure to meet inspection and criticism.

"It is Mengs who has done this," said many; but one, more acute than the others, pronounced the coloring better, but the drawing inferior to that of Mengs.

"There is no painter in Rome who could do it so well," was the warm reply.

Crespigni seized an auspicious moment when the interest was at its height, and pointing to West, nervous and anxious in the background, said: "There is the artist, gentlemen!" The impulsive Italians embraced him, and even the English present cordially shook him by the hand.

This strain and excitement in the mind of West reacted

on his physical nature, and, sick and exhausted, he was compelled to seek his lost equilibrium in Leghorn. Eleven months afterward West, with the warm hues of health once more mantling his cheeks, determined to visit the other centres of art, Florence, Bologna, and Venice. One serious impediment intervened—the money with which he had begun his career in art had dwindled to ten pounds. When he went to his agents to draw this his good genius stepped between him and the least shadow of anxiety about pecuniary matters that might have oppressed him.

"I am instructed to give you unlimited credit," said the agent. "You will have the goodness to ask for what sum you please." This was the result of the united generosity of Allen and Hamilton in Philadelphia.

West pursued his studies with a lighter heart and a heavier purse. To him, as to all others, the works of Titian were a miracle of coloring. For days he sat under their "lucid splendor," trying to solve the secret of the old Italian. But if the dead have a secret they hold it. As often as West thought to put his hands on it, so often did it evade his grasp.

After prolonged absence and study he returned to Rome and remained there long enough to give to us his first historical paintings, "Cimon and Iphegenia," and "Angelica and Medora."

There were many chords drawing him toward his native land, and thither he resolved to return, first allowing himself the gratification of a pleasure tour in England, the home of his forefathers. He arrived in London June 20th, 1763, but his good genius had been there before him and prepared everything for his reception. His munificent patrons, Allen

and Hamilton, together with Smith, happened to be there, and extended to the young artist the warmest welcome and introduced him to many people of distinction. He was delightfully entertained at Reading by his half-uncle, Thomas West. He looked on at Vanity Fair at Bath, and examined pleasurably the art collections at Hampton Court, Windsor, and Blenheim. Reynolds invited him to his studio, and to Wilson he had a letter of introduction from Mengs at Rome.

West was a shrewd observer. He had not intended anything more than a pleasure tour in coming to England, but once here in London he found Reynolds devoted to portaits, Gainsborough to landscape, Hogarth dying, Wilson unable to command attention, and Barry, poor, impetuous, high-tempered Barry, quarreling in Rome. Into whose hands should historical painting fall—if not into his? Such an opportunity comes but once in a lifetime. Seizing it, West without a word to any one, took chambers in Bedford Street, and set up his easel.

He sent his two historical pictures, painted in Rome, with a portrait of General Monckton, one of the commanders in the battle of Quebec, to the exhibition. These were well received, and from two dignitaries of the Church he obtained orders for pictures, "The Parting of Hector and Andromache" for one, and "The Return of the Prodigal Son" for the other. As early as this in his career this favorite of the gods received from Lord Rockingham the tempting offer of seven hundred pounds a year to adorn his Yorkshire home with historical paintings. This he wisely refused, acting on the advice of friends.

West had now fully determined to remain permanently in London, but he had still a strong motive for returning tem-

porarily to America. His engagement with Miss Shewell had remained unbroken through all these years. The morbid opposition of her brother continued as invincible as ever, and his demands for her marriage with the man selected by himself more urgent every day. Though he had sworn West should never see his sister, frequent letters were interchanged by the betrothed. In these it had been agreed that West should remain in London, and send for Miss Shewell, and she in obedience to his summons should come to London, and there be married. The summons was accordingly sent in the summer of 1765, but the brother, learning of the proposed escape of his sister and the ship on which she was to sail, had recourse to his old method, and placed the romantic girl under lock and key. Still holding fast to her pledge to West, she submitted to this, for when was there ever a woman unequal to the hardships imposed by love? While she was enduring this for her absent lover, an indignity to her womanhood, he was painting in London! Things approached a crisis. The day set for the sailing of the ship was close at hand. A relative of Miss Shewell's, sympathizing with her determination to go to West, was to serve as her escort to London, and had secured passage on the ship for himself and her. The brother, fearing to be overpowered or outwitted at the last moment, invited a number of friends, young gentlemen of the vicinity, to help him keep watch during the night preceding the departure of the vessel. This was to sail at daybreak. Miss Shewell was tightly locked in her room, and here were a number of his friends to aid him by resistance, if resistance became necessary. But Cupid was laughing at his bolts and bars, and was as busy as he in securing friends to aid him. Among Shewell's invited guests

were three friends, Benjamin Franklin, Francis Hopkins, and White, afterward Bishop. Before night fell, there had been a whispered consultation among these three, talks of a rope-ladder, and the employment of an emissary to climb to a window. The ship had been visited and the officers put on oath to sail as soon as a lady had been placed on board. This done, they repaired with others to Shewell's house. The night of watching was turned into a night of revelry. At two o'clock the din was loudest. Each vied with the other in telling the wittiest joke and singing the merriest song. Toward day they sobered down and the host, having fallen into a short doze, waked to find morning flinging its level rays into his face. Confident of his success, he went to release his sister; for, the ship having sailed, there was now no longer necessity for imprisonment. Opening wide the door, he was confronted by emptiness and silence. When Miss Shewell arrived in England, we are told, West went to the quay to meet her! How he wounded her gentle heart by his coldness, his historian has forborne to tell us, but he has taken the pains to say "she was a faithful and obedient wife for over fifty years, and their fireside had repose and peace." If he had loved her with a more absorbing tenderness, there might have been some storms about this model fireside; but after the storms would have come those delightful clearings and delicious calms holding a pleasure more intense than the model fireside ever dreamed of.

Following the ever-increasing good fortunes of the star of his destiny, West was invited to dine by Dr. Drummond, whose love for art was only equaled by his love for the classics. Calling his son, the formalities of the table being over, he bade him read from Tacitus the passage descriptive

of the landing of Aggrapina with the ashes of Germanicus. West seized the idea, and before he closed his eyes that night had sketched the scene. Drummond was so pleased that he initiated a movement to raise a subscription for West of three thousand pounds so as to enable him to devote his entire time to historical painting. He and his friends headed the subscription with fifteen hundred pounds, but the rest could not be raised. To another man the failure of this scheme would have been unfortunate, but to West disappointments were but blessings in disguise. To Archbishop Drummond the failure of his plan was a bitter wound, and he determined to enlist royalty itself in its behalf. He obtained audience with young King George, bestowed the highest encomiums on the picture West had painted for him, and suggested that his talents be secured for the throne and the country. The king sent for West, presented him to the queen, read to him a passage from Livy, and dismissed him with the command to paint for him "The Departure of Regulus."

It was while he was engaged on this picture that a discussion arose in the Society of Incorporated Artists, of which West was a member, as to what they should do with the funds they had accumulated. Several plans for its investment were submitted, West approving of none. The discussion growing warm, West, with Reynolds, quietly withdrew. These dissenters drew up a plan of their own, submitted it to His Majesty and received his approval and patronage. This was the foundation of the Royal Academy of Arts, in which "The Departure of Regulus" was placed during its first exhibition, and of which West himself was so long President.

West now by a *coup d'etat* made for himself a lasting monument and effected a sudden and wonderful change in the world of art. Historical painters had hitherto clothed their warriors of whatever nationality or period in the Grecian or Roman costume. In his "Death of Wolfe," West had the audacity to clothe his Englishman in the soldier dress of that period. Archbishop Drummond and Reynolds went to West during the progress of this picture and tried to dissuade him from so barbarous an idea. "I want to mark the place, the time, and the people, and to do this I must abide by truth," was West's answer to their objections. And Truth glorified her vindicator. No other historical painting has received such unlimited praise, and from this picture dates a revolution in art.

West's brush was now never idle. From his kingly patron he constantly received new orders. He painted at his suggestion eight pictures illustrative of the reign of Edward III. West expended much time and labor on these eight subjects, and they are considered his best works, "The Death of Wolfe," "Death on the Pale Horse," and "The Battle of La Hogue," excepted.

King George gave orders to West that his chapel be adorned with paintings illustrative of revealed religion. West became a Bible student, and pored over its sacred pages day and night. The result of these studies was thirty-six sketches, twenty-eight of which were executed, and for which West received twenty-one thousand seven hundred and five pounds. It was unfortunate for West that he ever conceived so sublime a flight. His imagination was not bold enough to climb to such a height, nor his heart warm enough to give to his pictures that glow that appeals irresistibly to

humanity. Besides many of these scenes had already been traced by other and diviner hands, and his touch had in it something of profanation.

Sir Joshua Reynolds, President of the Royal Academy since its foundation, having died, West was unanimously elected to take his place, and he continued to hold this position till 1802. In this year he resigned and Wyatt was elected in his stead, but only held the honor one year, when he was displaced and West unanimously re-elected. Death alone removed him from this distinguished position.

West was now over sixty-four. The illness of the king having caused a suspension of his work for the chapel, he commenced a series of Scriptural subjects on his own account. The first of these was "Christ Healing the Sick," which he painted for a Quaker hospital in Philadelphia, but being offered three thousand guineas by the British Institution, he sold the picture and sent a duplicate to the hospital. The success of this picture increased the boldness of West's conceptions, and he ventured to depict the grandest visions of inspiration, but his imagination, tired with too long tarrying in this exalted atmosphere, flagged and fell. He imagined himself an eagle, capable of sustaining himself at will upon the boldest crags of inspired thought. Instead, as often as he essayed the heights, his weary pinions, crippled with old age, bore him remorselessly back to earth.

Elizabeth, his tender and obedient wife, died December 6th, 1817. Consecrated by death, West realized what inspiration he had drawn from her gentle spirit. He continued to paint three years longer, but his right hand had forgot its cunning. On the 11th of March, 1820, in the eighty-

second year of his life, he fell in death from perfect ripeness, as

> "The full-juiced apple, waxing over-mellow,
> Drops in a silent autumn night."

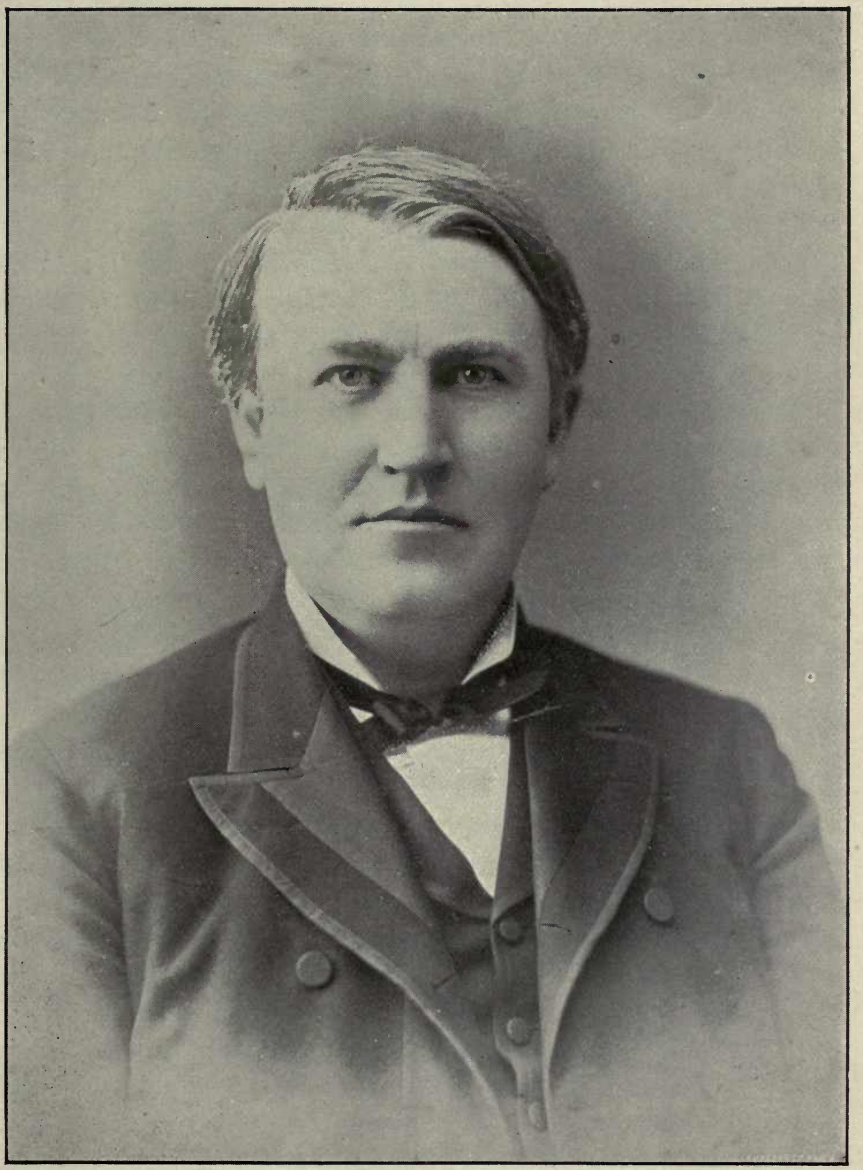
He reposes by the side of Reynolds, Opie, and Barry, in St. Paul's Cathedral, London.

It is unfortunate for posterity that West walked forever in the sunshine of prosperity. We cannot think he fulfilled the promise of his early childhood. His conceptions were of the grandest, his execution careful and exact, but his pictures, with one or two notable exceptions, were not humanized and vitalized by personal feeling and suffering. He had never felt intensely, and had never suffered—how then could he put into a picture that which, while it draws tears from the eyes, warms and ennobles the heart? As a mortal, he had a personal conception of Death, the All-Conqueror; hence we find the grandest of his pictures to be "The Death of Wolfe" and that solemn and weird creation, "Death on a Pale Horse."

## THE ELECTRIC LIGHT.

IT is almost within the present decade that John T. Sprague, an eminent electrician and telegraphic engineer in England, added a postscript to his work on *Electric Lighting*, in which he noticed "a report that Mr. Edison had invented a remarkable dynamo machine," and further observed that "Mr. Edison apparently promises more than he can perform; neither he nor any one else can bring more out of electricity than there is in it; and the report savors considerably of *newspaper science* and exaggerated statement." Even up till a very recent period it was generally considered that it was impossible to subdivide the electric current as to distribute the light from a number of small lamps so as to make it of practical value otherwise than in large buildings or out-of-door spaces. But the latest writers agree with the spoken opinion of the experienced practical electricians of to-day that the science of electric illumination is yet in its infancy, and the field of exploration unlimited.

From Oersted's discovery in 1820 that an electric current could be made to deflect a magnetic needle, came the gradual evolution of the electric telegraph; from Sir Michael Faraday's discovery, a few years later, of the phenomena of magnetic induction, came the electric light. From the period of Faraday's discovery, many scientific minds were at work in-



THOMAS A. EDISON.

dependently for years on the problem of turning it to practical account. Eventually, in about twenty-five years, F. H. Holmes designed, and had perfected, a machine for the generation of electric light, which was exhibited in London before a body of scientific men. Faraday was present at this exhibition, and was delighted with the results attained, saying to Mr. Holmes, "*Remember*, this, *my baby*, but you have made a man of the infant." This Holmes machine was approved by the Masters of the Trinity House, and the first light-house illuminated was the South Foreland, in 1858.

Henceforth the subject of electric illumination became fascinating to all electricians. From Faraday's discovery that an electric current set up by the rotation of a conducting wire among the lines of force of a magnet would produce light, the idea developed in successive stages, until from the little experimental machines used chiefly for amusement (or curative purposes by physicians) have arisen the elaborate apparatus capable of generating immense amounts of electricity, and requiring the working force of powerful and specially adapted steam-engines.

The inter-dependence of scientific discoveries is illustrated well by the necessary coeval invention, for electric purposes, of driving engines of a peculiar character; these requiring to be plain, substantial, and having continuous motion; for the engine may not cease working one moment so long as the light is required to blaze.

Electric illumination is the finest lighting power as yet discovered. Its immediate predecessor, gas, produces light and heat by the direct combustion of the volatile parts of coal at the point where these are required, and both consumes and poisons the air surrounding the points of combustion. With

the electric light, the consumption of air takes place within the furnace instead of at the burner, therefore consumes no outer air, and exhales no noxious vapor; it converts the power latent in coal into light, but by a different process; and has the further advantage of possessing all the colors forming perfect light, and therefore, unlike gas, shows all colors in their true shades. This quality makes electric illumination invaluable in dye-works, the rays of the voltaic arc rendering it easy to match all colors in every shade.

The value of this new light having been proved, the next step was to overcome the difficulty of dividing the electric current so as to form a number of individual lights of less intensity than that one supplied from the whole current. This problem was solved by the use of alternating currents and regulators working with the continuous current.

In 1867 S. A. Varley, Sir Charles Wheatstone, and Dr. Siemens (each prosecuting their ideas quite independently) made the identical discovery of the principle of the re-action of electro-magnetic currents, and, without any previous consultation, Siemens and Wheatstone announced their discovery to the Royal Society on the same evening. This discovery gave birth to the "dynamo" machines now in use.

Inventors in this line of science multiplied, whose names (Edison, Lane, Makin, Swan, Lane-Fox) are familiar as household words; but forty years before Swan in England and Edison in America almost simultaneously demonstrated the practicability of the idea of electric illumination, the inventor Starr took out a patent for incandescent lighting.

Although in the earlier days of the new light Edison's inventions were but coldly received, he is generally considered the pioneer of the now established systems; and the dis-

tinctive peculiarity of his own system, viz., the distribution of currents from the main generator, has its value fully acknowledged.

The great light is winning its way all over the civilized globe, and its indirect value extends over diversified spheres of life. It is stated on the authority of indisputable statistics that in one district of New York alone—the Bowery—street-crimes have diminished sixty-five per cent. since the introduction of this powerful illuminator. It has opened new fields of industry to intelligent workmen, and employs an army of people in every great city, who spend their whole working life underground.

The rapidity with which electric illumination gains ground is among the marvels of modern scientific evolution. In 1880, the largest installation of electric light then known was that of the Savoy Theatre in London—about two hundred lights. Now, the Auditorium at Chicago has an installation of three thousand lights; while at the Melbourne Centennial Exhibition of 1888, two thousand Edison and Swan incandescent lights, and nine hundred and fifty British arc lights were in use; besides five lights of four thousand candle power each in the dome. Each lamp lighted one thousand one hundred and fifty feet of floor surface. The massive machinery of this enormous plant was chiefly of Victorian manufacture, and included three pair of driving engines, with twelve boilers each of fifteen hundred horse-power, and forty-two dynamo machines.

## AERIAL NAVIGATION.

MAN is the superior of all created beings, the crowning triumph of the divine workmanship. His intellect, his spiritual nature raise him to a plane where he can comprehend the infinite mind, can know in part the infinite thought originating and pervading the world. And yet, the tiniest bird that floats an airy speck in the blue vault above him has a gift that man in his might deigns to envy.

"Oh! that I had wings like a dove!" has been the sigh of aspiring humanity since the world began, but the secret of the bird's flight has been locked in its own feathered breast, defying the questioning eye that would search it out. It has seemed to man a humiliating thought that a little bird should flap its wings triumphantly over his head, and soar away till its exultant carol was lost in the azure distance. Darius Green is not the only chagrined mortal who has propounded to himself the indignant query:

> "The birds can fly, an' why can't I?
> Are the blue bird an' phebe smarte'n we be;
> Does the little chattering saucy wren,
> No bigger'n my thumb, know more 'n men?
> Just show me that, or prove that the bat
> Has got more brains than's in my hat,
> An' I'll give in, an' not till then."

Envy is the first step toward imitation. Man saw fishes swimming in the sea, he studied their movements, and constructed himself barks whereby he might skim the waves as well. And, in like manner, the genius of men has been for ages contriving, devising, and experimenting, if perchance it could invent an apparatus that should make possible for human beings the flight of the swallow.

The endeavors to construct flying machines are as old as history. Some iconoclastic realists, who would reduce every cherished myth to the terms of probability, would have us believe that even the mythological Dædalus, whose vaulting ambition led him to fly so near the sun that the scorching solar rays disastrously melted his newly-donned wings of wax, causing him to fall with a "dull, heavy thud" to the earth, was but the precursor of the latter-day aeronauts, and that the mythological tale is but a gently symbolic way of conveying that his venture was a failure.

The followers of Dædalus have many of them shared his unfortunate fate, but others seem in no way deterred by this from new undertakings. One Simon Magus, in the reign of the Emperor Nero, is said to have fallen and been dashed to pieces while essaying to fly from one house to another. In the fifteenth century, a mathematician by the name of Dante planned and executed a more successful experiment. By means of artificial wings securely fastened to his body, he was enabled to raise himself above Lake Thrasimene. Other inventive geniuses have at divers times believed that they had at last grasped the secret of sustaining and propelling a body in the air, but their machines when put to a test have ever been found lacking in the one thing needful to constitute flying.

The feat of lifting one's self into the air was attained with the invention of the balloon. The discovery of hydrogen gas by Cavendish in 1766 suggested to scientists a practical method of aerial navigation. Some experiments made by Mr. Cavendish with hydrogen, revealed that that gas was sixteen times lighter than common air. It would therefore rise to a height at which air is sixteen times lighter than it is at the surface of the earth. This discovery suggested to Dr. Black, a professor of chemistry in the University of Edinburgh, the idea of the balloon. He inferred that a bag filled with hydrogen gas would rise in air. He accordingly constructed a large skin bag, which he filled with this gas, but his experiment was unsuccessful, owing to difficulty in obtaining a material for the bag which should be at the same time of sufficient lightness and impervious to air.

To two brothers, Stephen and Joseph Montgolfier, paper manufacturers at Annonay, France, who had previously distinguished themselves by the invention of a machine called the hydraulic ram, belongs the honor of sending up the first balloon. Their first ascent was made in June, 1793. The balloon used on this occasion was made of canvas, lined with paper, and weighed five hundred pounds. They had devised a means of filling the bag with hot air, from a fire made of bundles of chopped straw. It is doubtful if the Montgolfiers themselves fully understood the principle underlying the elevation of their balloon, they seeming to attribute it to the ascending power of the smoke which filled the bag, rather than to the actual cause, the rarefication of the heated air. The balloon, on being freed, rose rapidly to a height of about a mile, remained suspended in the air for several minutes, and fell at a distance of a mile and a half from the starting place.

The news of this experiment spread to Paris where it caused a great sensation. M. Charles, a celebrated lecturer on natural philosophy, was led to supervise a second experiment, which was made in August from the Champ de Mars. Success attended this exploit, and now that the possibility of raising a bag was assured, the experimenters cast about for a means of carrying persons up with the balloon. As yet, no one had hazarded so doubtful a journey.

Two young men named Pilâtre de Rozier and Marquis d'Arlandes were the first to accomplish this feat, making an ascent of three thousand feet, and returning to the earth in safety. The early experiments were mainly made with the Montgolfier balloon, filled with heated air. The aeronauts were obliged to carry with them a supply of fuel to renew the rarefied air as rapidly as it escaped, and from this fact resulted some disastrous accidents.

Ballooning was now fairly inaugurated. New inventions, modified and improved on the original models, and yet, in all its essential features, the balloon of to-day is a prototype of its predecessors. In place of heated air or hydrogen for inflating the bag, however, aeronauts have of late years substituted carburetted hydrogen, or common coal gas, which has a mean density of about one-half that of air. Mr. Green, the English aeronaut, first introduced this improvement.

No sooner was ballooning demonstrated to be a success than its application to practical purposes was sought. This was a most difficult task, since, although buoyancy was secured with the balloon, to pursue a course in the air involved other considerations. From their ability to rise to great heights, however, balloons were early pressed into the service of scientific investigators, and much valuable information in

regard to upper air currents and variations of temperature at different altitudes has resulted from these aerial explorations. To these expeditions, astronomy is, of course, a debtor, although not so largely so as would at first seem probable. Among the most successful of balloon explorers have been Mr. James Glaisher, F. R. S., of England, and Messrs. Camille Flammarion, W. de Fonville, and Gaston Lissandier, of France.

The majority of the ascents which have been made since the invention of the balloon, and which number many thousand in both Europe and America, have been for the amusement of a multitude, as a popular spectacle, rather than for any scientific or useful purpose. Skillful and daring aeronauts have not been wanting, who have astounded, and, at the same time, terrified the spell-bound spectators. Of the later French aeronauts, Eugène and Louis Godard have been the most famous. The English aeronaut, Green, had during a professional career of thirty-six years probably a wider experience with the balloon than any other person. He made nearly fourteen hundred ascents, crossing the sea three times, and twice falling into it. In 1836 he, in company with two other persons, sailed in an enormous balloon, provided with provisions for a fortnight's journeying from London to Weilburg, a distance of five hundred miles in eighteen hours. A feat of aerial journeying distancing even this was, however, accomplished by Mr. John Wise, the American aeronaut. With three other persons, he journeyed from St. Louis, Missouri, to Jefferson County, in New York, one thousand one hundred and fifty miles distance, in nineteen hours and fifty minutes, being an average rate of a mile per minute.

A balloon voyage across the Atlantic was projected in 1873,

which, although it never took place, was famous for the extent of the preparations made. The balloon was to be of unbleached muslin, coated with a varnish made of linseed oil, beeswax, and benzine. It was to be one hundred and ten feet high, and one hundred feet in diameter, with a gas capacity of six hundred thousand cubic feet. A boat was to be attached, which should have water-tight compartments, and should be self-righting. A complete outfit of oars and sails was to be provided, and provisions in water-tight cases sufficient for a thirty days' journey. The weight of the balloon, car, and all accessories, was to be seven thousand one hundred pounds. That this much-talked-of voyage never occurred is to be regretted, since it was expected by scientists to solve many yet unsettled problems of balloon sailing.

M. Camille Flammarion's celebrated voyage from Paris is one of the most unique of aeronautical excursions. The occasion was none the less romantic than the mode of transit, being a bridal journey. In his inimitably charming language the great astronomer describes the ascent into the air from Paris on a perfect summer evening. The city recedes beneath them like a fair picture, while they approach to the region of the moon and stars. Battle-fields, hamlets, and rivers are passed over in their brief tour, which, although it occupied only six hours, was replete with delightful experiences.

Shortly after the invention of the balloon, it was imagined that they might be rendered useful for purposes of observation in time of war. An aeronautic school was established at Mendon, France, and balloons were distributed among the French armies. General Gordon is said to have owed his victory in the battle of Fleurus, in 1794, to information about the Austrian positions and movements obtained by French

officers stationed in a balloon. The balloon was held by a cable, but so arranged that the observers could soar above the fire of the enemy.

In the American Civil War, balloons were again made use of, with valuable results. Early in the war the United States War Department organized a balloon corps, placing it under the management of Messrs. La Mountain, Lowe, and other experienced aeronauts. The feat of telegraphing from an aerial station six hundred feet above the earth was first accomplished by Mr. Lowe. This achievement was fraught with momentous importance, and, during the spring and summer of 1860, many balloons were sent up. So useful was this balloon corps found to be that it formed a part of General McClellan's expedition to the Peninsula, in 1862. These balloons were made of the best and finest description of silk, the varnish, on which much of the success depends, being a secret of Mr. Lowe's. By the application of this varnish, his balloons were made to retain their gas for a fortnight or more, and this quality, it will be readily understood, was for military purposes a most important one.

The balloon staff consisted of one chief aeronaut, with rank not lower than captain nor higher than brigadier; one assistant captain, and fifty non-commissioned officers and privates. The apparatus consisted of two generators, two balloons, and an acid cart. Frequent ascents were made by these balloons, and a report of his observations was sent daily by the aeronaut to General McClellan. In clear weather the balloon could, at a height of one thousand feet, command an effective range of vision for ten miles or more.

While the army was before Richmond, the balloons were

constantly in use, and the reports were anxiously awaited. During the first two days of heavy fighting, a telegraph instrument was taken up into the car, the wire placed in communication with the line to Washington, and reports sent thus directly above the field of battle to the Government. General Fitz-John Porter barely escaped, on one occasion, a disastrous termination to his aerial observations. While he was watching from a captive balloon the enemy's movements, the cable which secured the balloon suddenly broke, and he drifted over the Confederate lines. He hastily pulled the valve-string, thereby causing the machine to descend, when a current of air going in an opposite direction was reached, and he was landed in safety within the Union lines. At the battle of Fair Oaks, Mr. Lowe, who watched the conflict from a balloon, was the first to make known the enemy's retreat to Richmond. The balloon corps was disbanded after McClellan's retreat to Harrison's Landing, and no further use seems to have been made of balloons for military purposes during the war.

It was during the Franco-Prussian War that balloons were next pressed into active service. At the commencement of the war, the French Government had rejected a proposal to supply the army with balloons, deeming them of little practical utility, but the siege of Paris by the Germans, in 1870–71, demonstrated that a balloon is the most feasible means by which the inhabitants of a besieged city may communicate with the outside world.

The Parisians found themselves cut off from intercourse with the outside, with no machine which could be trusted to pass over the besieging lines in safety. Balloon factories were speedily established in two of the principal railway

stations, and nearly seventy machines were made previous to the capitulation. The material of the bags was calico, varnished with a mixture of linseed oil and oxide of lead, and the balloons were of an average capacity of seventy thousand cubic feet.

The first balloon left Paris with two hundred and twenty-seven pounds of letters, and landed in safety at Evreux. The work accomplished by balloons during the siege was no less than sixty-one voyages and the carrying of two million five hundred thousand letters. Most of the balloons took with them carrier pigeons, which were intended to bring back replies to the letters, but a comparatively small number of the pigeons ever returned to Paris. Since these little birds were capable of carrying only a light weight on their return journey, long letters and messages were reduced by photography to within a space of one or two square inches, on the thinnest kind of paper. When these messages were received they were read by means of a microscope, and transcribed into readable form. Several balloons fell into the hands of the enemy, and three have never been heard from since they left Paris. One, the "Washington," while crossing the Prussian outposts, at a height of three thousand feet, was attacked by so severe a fire from the enemy that the travelers were forced to ascend hastily several hundred feet to escape total demolition. Attempts were made to send the balloons by night to escape the enemy's firing, but these journeys were found to be too hazardous, since the aeronauts were unable to determine their direction of traveling or their distance from the earth. Among persons to make use of the aerial highway was Gambetta, who left the city by this mode of transit, in order to enter upon the control of affairs at Tours.

Serviceable as the balloon has proved in times of war, it is yet seriously doubted by scientists whether it can ever be widely utilized as a means of travel. This is because of the failure thus far to apply any means of steering a balloon which shall enable the aeronaut to pursue an exact course through the air, landing where he will. No one has yet been able to successfully guide a balloon in a horizontal direction, and easily as a balloonist may ascend to great heights, he is largely at the mercy of the winds after having ascended.

Becoming convinced that the problem of aerial navigation will not be satisfactorily solved by the balloon, the "Aeronautical Society" has been of late years established in England, numbering among its members many distinguished men, for the purpose of investigating other means of sailing the air.

Is there, then, a reasonable probability that men will one day fly through the air as now they sail the ocean? Men of science answer decisively, Why not? The act of flying is not conditioned by vitality. It is purely a mechanical action. It consists merely in the adjustment of certain physical forces to the production of motion. These forces are essentially the same as those which man has subjected to his use in other fields, and under conditions apparently as insurmountable. Once the action of these forces is understood, success should be attainable. It is because men have had incorrect theories as to the principles governing the bird's motion in air that they have failed in their attempts to imitate it. The mechanical conditions of flight must be thoroughly understood to be reproduced.

The end to aim at in the construction of a flying machine is that it shall apply to the air the same conditions imparted

to it by the mechanical wing action of a bird. The bird, by this motion, sustains in air and propels with ease a weight out of all apparent proportion to the surface of its wing. When men shall have fully mastered the principles governing the action of surfaces at different velocities upon elastic and yielding media, as air, when they shall have learned how to obtain a power for a lever upon an unstable fulcrum, they will be not far from the solution of the mystery of aerial navigation.

How to combine the greatest lightness with the greatest strength is the problem, and the hollow bones of the bird are in this regard the proper model for the builders of aerial machines. A motor power light enough and yet powerful enough to perform the service required has yet to be discovered, but that such a power will in time be found who, in the light of past achievements, can doubt? He who has chained the steam to his car, and made electricity the servant to do his bidding will not surely despair of further conquests. Rather, he will believe that there is no limit to the inventive genius of man, and will rest satisfied only when he has made himself master of every physical force.

What the navigation of the air will open up for humankind, imagination can only dream of. We may not even, with airy navies, be on visiting terms with Mars or Venus. We may not yet discover if there are dwellers on the other side of the moon. But one thing is assured. It will usher in an era of swifter transit than the world has yet known. It will bring nations nearer together than even railroads or telegraphs have done, and would be, indeed, a fitting climax to the wonderful achievements which the present century has witnessed.

# FIREARMS.

"I SING of arms," sang Virgil, and it is of arms and their achievements that most of the poems and histories of the world have been written. The production of weapons for military purposes is one of the first acts to which the energies of a primitive people are directed. They originate with the earliest necessity for national defense or desire for national aggression. Swords, arrows, and battle-axes are implements of the least civilized, the wholly barbarous races. The origin of weapons is therefore almost co-existent with the origin of mankind, and a study of the agents with which the world has fought its battles must ever be an interesting one.

With the invention of firearms was inaugurated a new era in the history of warfare. In the generic term firearms are included all weapons whose action consists in the propulsion of projectiles by means of an explosive. The existence of firearms is wholly dependent upon a certain hidden quality of gunpowder. Inflammable material was employed by the ancients in warfare. Sulphur and resinous gums, or naphtha and bituminous substances, constituted the materials known in remotely antique times, as "Greek fire," "wild fire," or "Media's oil." These compounds were deflagrated in vessels which could not be denominated firearms.

A weapon similar to a Roman candle of the pyrotechnists was invented by some of the Eastern nations, and in extensive use up to the fifteenth century, in warfare and for the purpose of frightening horses and cattle on pillaging expeditions. This instrument consisted of a tube filled with Grecian wax and metal filings alternated with layers of gunpowder and balls of tow mixed with sulphur. The weapon was discharged by lighting it at the muzzle, when the filling burned down till it reached the gunpowder, which, igniting, shot out the balls.

Gunpowder and firearms were used by the Arabs in the eighth century in the form of weapons known as "manjaniks," which they introduced into Spain in the thirteenth century. Cannon were employed to throw stones at the defense of Seville in 1247, and shortly after these machines figured in other military contests. In 1350 the North German knights were said to have been armed with iron guns, and Einbeck was, in 1365, defended by firearms.

These early firearms were known to their users in different countries by different names, such as "bombardo" in Italy, "buchsen" in Germany, "quenon" in France," and "crack-eys" or "engynnes of war" in England. It was not before the fifteenth century that firearms were classified and named accordingly. The forerunners of the modern bombs or mortars were the "bombards," short vessels from which stone balls were shot at a short distance and considerable height, and with a small charge. Early firearms were usually loaded to the muzzle and fired at an extreme angle.

The first form of hand firearms to be used was a combination of firearm with another weapon, its effectiveness depending largely upon its unexpected firing, taking the enemy unawares. With this same intent double-barrelled

and repeating weapons were employed. Frearms were combined with daggers, swords, axes, and shields, and other forms even were devised for rendering the explosive weapon doubly destructive in the hands of the warrior. The consternation produced by the sudden and unlooked-for discharge of firearms probably contributed no less to their success than the actual effect of the projectile hurled. The hand firearm seems thus to have been first introduced as a concealed weapon, pistols being even inserted in the handles of whips carried by Neapolitan brigands and French postillions.

The culverin or hand cannon consisted of a handle of wood or iron, to which was attached a small tube one-half or three-fourths of an inch in internal diameter. These were used largely in the latter part of the fifteenth century. They are said to have been employed in the army of Edward IV, after his landing at Ravenspur, Yorkshire, and hand culverins figured prominently in the siege of Berwick in 1821. The smallest hand culverins were about four feet in length, having a weight of about fifteen pounds. These were used by cavalrymen, while the larger weapons, weighing sometimes as much as sixty pounds, were fired by foot soldiers. These large culverins were always supported upon a forked rest, and an attendant called a "varlet" accompanied the culverineer to assist in firing the piece. A smaller and improved form of culverin was the arquebus, which was capable of being operated by one man. This was first used at the battle of Morat, in 1476. In the matchlock arquebus a hinged lid covered the flash-pan, and the serpentin or lever which held the burning match was forcibly thrown upon the touch powder in the flash-pan by means of a spring, but ordinarily the burning slow-match was lowered by pulling the lower end of

the serpentin toward the stock. Descended from the match-lock arquebus were the hagbut, hackbutt, hackenbuse, and musket, the latter being formerly a heavier weapon than the modern form, carrying a double bullet.

The loading of these early firearms was a slow and difficult performance, necessitating a deliberation in firing incredible to modern combatants. At Kissingen in 1636 and at Witten Mergen in 1638 seven shots were said to have been fired in eight hours. This slowness of action was said to be due to the fact that the musketeers were compelled to load the instrument while the forked rest was attached by a thong to the wrist, and that during this proceeding they were continually harassed by the opposing cavalry and archers.

With the invention in the latter part of the sixteenth century in Germany of the wheel-lock, the use of firearms for sporting purposes was more generally adopted. The wheel-lock originated from a gun, in which pieces of pyrites were placed near the flash-pan and ignited by the friction produced by a file rubbed against them. In this weapon a spring pressing against the end of the lever opposite to the one in which the flint is fired holds the flint in the flash-pan. A grooved wheel, with serrated edges, is revolved in the flash-pan by means of a chain and a flat or V spring. This wheel was wound up as is a watch with a movable key. Upon the pulling of the trigger, it was released, and rotating swiftly against the flint, it produced ignition. The wheel-locks were not used extensively out of Germany and Italy, but the Saxon collection of these weapons in the British Museum shows that their invention was at one time considered of great importance.

The flint-lock, which originated in Spain as a cheap substi-

tute for the wheel-lock, was said to have been produced by marauders, who dreaded exposure of their presence by the burning match of the arquebus. It was introduced into the English army in the reign of William III, where it continued in use until 1840.

For some time after the cannon was invented, it consisted of a weapon with an extremely small bore, scarcely larger than were the muskets of the eighteenth century. Leaden bullets were discharged by these. Had it not been for their heavy workmanship, necessitating small carriages for conveying them, they would doubtless have been used as hand firearms. Cannon have not a common history, although a common origin with pocket pistols. Various materials have been used in the construction of cannon. In 1378, at Augsburg, they were cast of copper and tin alloy. They have been made of hollowed blocks of stone, of wood, of rope, of leather, of papier-maché. In fact, almost every pure and alloyed metal which it is possible to forge has been used in the manufacture of these weapons. They have even consisted, as at Alexandria, Constantinople, and Gibraltar, of cylindrical holes bored in the solid rock, filled with explosives, and used to fire projectiles.

In early warfare cannon were used chiefly in besieging cities and forts, their weight, combined with the poor roads, making transportation difficult, as well as the inefficiency of the early machines themselves, rendering them of slight utility as field pieces. When used in battle they were fired but once.

The cannon developed on the one hand into small, portable weapons, hand firearms, and, on the other, into the enormous instruments used in the defense of fortifications. One of

these ancient instruments is the "Mons," of Edinburgh Castle, which weighs nearly four tons, and fired a stone shot of over three hundred pounds. The powder chamber of this early cannon exhibits a principle, the reverse of the modern one, of enlarged powder chamber, being of a less diameter than the bore, resembling in this respect the mortar. Cannon similar to this were manufactured at Ghent, in the fifteenth century.

Field pieces were not greatly developed until the eighteenth century, when an improved finish of the interior was attained, allowing a long and uniform range and accuracy of aim. Improvements in cannon and quick-firing guns have depended less upon the genius of inventors than on the evolution of mechanical science, which has led to accurate workmanship and ability to work large masses of material. Improvements in explosives in the quality of the metal, and in the machinery available have rendered possible the production of field pieces of prodigious size. The limit in this direction would seem to be rather in the cost of manufacture than in human ability to construct them.

To impart steadiness to a projectile and increase its accuracy is the problem which scientific artillerists for a long time strove to solve in the construction of their weapons. The invention of rifling secured the attainment of these ends. Rifling consists in the cutting of grooves in the chamber of the gun barrel, which, by gripping the ball, cause it to rotate round its axis, and thus to be ejected from the barrel more closely in line with the axis of the bore.

The first rifle known to be used was in 1563. In the latter part of the sixteenth century Augustus Kutter, of Nuremburg, invented a rifle with grooves in a spiral form, and in

1662 the Bishop of Munster originated the idea of elongated projectiles for use in such rifles.

Rifles were adopted into the British service in the year 1800, the old Ninety-fifth regiment, afterward known as the Rifle Brigade, being armed with Baker's rifles, so named from their inventor. This rifle was used by British soldiery until about 1835, when it was replaced by the "Brunswick" rifle, invented by Major Berner, in the Brunswick army. With this rifle the percussion lock first appeared in the British service. By 1842 all the prominent countries of Europe had adopted some form of rifle in their armies. About this date the Prussians discarded the old smooth-bore musket and armed their militia with the celebrated needle gun, "Zundnadelgewehr." This weapon is a bolt gun, with the needle contained in the bolt. On firing the gun the needle is pressed through the powder charge, and strikes the cap in the rear of a papier-maché plug, so that the charge is ignited from the front, it being thought that by this means the bullet encased in the plug will be less likely to be detached from its case. The plug receives the rifling and imparts rotation to the bullet.

A Frenchman, Captain Minie, in 1849 invented the rifle known as the Minie rifle. This rifle marked a change in the form of bullet used, the spherical bullet being in this superseded by one of a cylindro-conoidal form. This weapon was speedily adopted by the French army, and later by the English. The English army which was sent to the Crimean war armed with this rifle, possessing in its use a great advantage over their Russian foes.

Numerous inventions have, from time to time, improved on the rifle as originally constructed, until it has at the present

day a marvelously intricate and effective weapon. The magazine rifle was an important advance in artillery. In this a magazine or case is attached to the gun, being worked by a mechanism actuated by the breech action, by means of which four or more cartridges are fed consecutively into the gun barrel. In the Turko-Russian war in 1877, the great efficiency of this rifle was demonstrated. During the Russian assault before Plevna, the Turks, armed with Winchester repeating rifles, slew the Russians by hundreds as they advanced to the assault. The rifle at present used by the United States troops is the Lee magazine rifle, but the Winchester and other small bore repeaters are also in use by a part of the army.

The carbine is a short rifle, precisely like the infantry rifle, with the exception of being a foot shorter, and chambered for a smaller cartridge. All cavalry soldiers in the British army carry Martini-Henry carbines in leather cases for use when on foot. Gunners of garrison batteries have the same weapon with a sword bayonet to fit on to it, both of which are strapped to the foot-board of each limber in field batteries.

The pistol, the smallest form of firearm, was first made in 1540, by Camillio Vetelli, at Pistoia. It was evolved from a small hand cannon called "poitrinal," and was at first used as a concealed weapon, being first adopted for military purposes by the German Ritters. The pistol figured in the defense of the French by the Ritters in 1554. In the eighteenth century double and four-barrelled pistols were commonly used, and the revolving pistol preceded the invention of the revolver of modern times. For military and police purposes in civilized countries the revolver has superseded

the pistol. The duelling pistol, a model of workmanship, and the twenty-pace pistol firing a large bullet with a small charge of powder, as made in Paris at the present time, are not equalled as weapons of precision by any firearm manufactured.

The revolver is a firearm in which the barrels or chambers revolve upon a common centre, and are in turn fired by one lock mechanism. The first appearance of revolving weapons was in the seventeenth century, and the earliest form consisted of hand guns of two or more barrels invented to turn upon an axis, the powder pan being brought successively under the action of the lock. The barrels were turned by hand, instead of being rotated by pulling a trigger. A Parisian gunsmith, Le Norman, produced a weapon in 1815 with five barrels. Another was later invented, having seven, but these were neither of them found practicable. The famous Colt revolver was invented by Colonel Samuel Colt in 1835. This has a rifle barrel, a revolving cylinder with six or seven chambers, and a level trigger which operates the mechanism devised to turn the chambers and fire the weapon.

Since killing is not only a serious, a tragical business, but is also supposed to be a sport, special classes of firearms have been constructed for the use of the sportsman. The term gun, although having formerly a wide range of application, is now especially employed to distinguish the sporting gun from the military rifle. Firearms for sporting purposes are the shot-gun and the rifle, the latter for large game shooting.

Sportsmen in Germany in the sixteenth century used hail shot, and after the invention of the arquebus, the wheel-lock

came into general use for sportsmen. The first double-barrelled guns were manufactured for use in war, but Italy, in the seventeenth century, produced guns with two barrels side by side. The art of shooting on the wing was first attempted about 1580. With the development of better forged barrels in the latter part of the eighteenth century, the fowling piece, a light, double-barrelled gun, was made possible, and this instrument has continued to increase in strength and lightness.

The sporting rifle dates back to the time of the wheel-lock hunting weapons of Germany. It is peculiarly adapted for large game shooting, where the main essential is the rapid firing of a second shot, together with a paralyzing effect from the bullet. In a military weapon, on the other hand, length of range, with shots following each other in quick succession are the great desiderata. The average muzzle velocity of the military rifle is fifteen hundred feet per second, while that of the express or sporting rifle is two thousand feet per second, force of impact being sought in the latter rather than accuracy and extent of range. The largest military rifle may approach this greatest velocity, but the force at impact is still less than that of the sporting rifle projectile.

The best military small arms, rifles, may be used at a range of two thousand yards, and the best sporting rifle at three hundred yards. Two-thirds of the charge of a shot-gun will be deposited within a circle thirty inches in diameter at a range of forty yards, and the last shot of the charge will be found not over ten feet behind the first reaching the target at that distance. The average shot-gun has a range of about forty-five yards, while the range of wild-fowling guns with seven shot, is about one hundred and forty yards.

The modern shot-gun is invariably breech-loading, and usually upon the "drop-down" principle. The welding of shot-gun barrels is an interesting and difficult performance. They are generally hand-forged from a rod composed of two different varieties of iron, or of iron and steel. It is necessary that one of the metals should be softer than the other, the excellence of the completed barrel depending upon the greater proportion of the harder metal used in its construction. There are many different methods of twisting together these two different kinds of metal, the Belgians being especially expert at this, combining in some cases as many as six different twisted rods to form a single riband. The English barrels are, however, of greater hardness than those of the Belgians, and are generally considered superior to the latter.

Shot-guns are now manufactured in much lighter form than when breech-loaders first came into use, and shorter barrels are employed with no loss of shooting power or apparent increase in the volume of recoil. Smokeless explosives are in general use for shot-guns in all countries. The best class of shot-guns are now highly perfected, and little further improvement may be looked for in them, unless something new in the form of explosives be invented or some new means of using shot-guns be developed.

The Continental gun-makers were formerly considered superior to the English, but the English guns now rank above all others, recent English inventions having effected great changes in the arms of that country. The Italian and Spanish smiths have been particularly noted for their superior workmanship in the manufacture of firearms, as in that of other implements wrought of metal. The most curious arms were

those produced at Paris, Amsterdam, Liege, Hanover, and Lisbon.

Since it is the demand for an article that regulates the supply, the impetus given to the invention and manufacture of firearms has been the wars in which nation pitted against nation has had recourse to all that science could discover and genius could originate to secure the balance of might. The wars of the Middle Ages did much to promote the invention and to improve the existing forms of military weapons, while the Franco-Prussian war of 1870–71 has resulted in the manufacture in France and Germany of the best repeating rifles in the world.

The most important improvements have been in the line of the ignition of the charge of the explosive. The French chemists of the eighteenth century produced fulminating or detonating powders, and their experiments led to the invention by an Englishman about the year 1800 of a highly sensitive explosive compounded of fulminate of mercury and saltpetre. It was, somewhat strangely, to a Scotch clergyman, Alexander J. Forsyth, that the origin in 1807 of the detonating principle for exploding gunpowder in firearms was due. A French invention of much importance was the cartridge case containing its own means of igniting. The success of modern breech-loading fire small arms is largely due to this instrument, which is used for all quick-firing machine guns as well as for some of the smaller cannon. The making of firearms by machinery was introduced into England in 1856.

As inventions have changed the conditions of industrial activity, so they have rendered modern warfare a widely different thing from what war was when men fought with swords or axes hand to hand. The battle of Homer or Virgil

has few points in common with a military contest in the latter half of the nineteenth century. In one view those primitive encounters were more brutal, more repellant, when, from behind a shield, the warrior hacked viciously at the body of his enemy. But in the extent of its results the long-range battle of to-day is infinitely more terrible. The Krupp gun, with its marvelous capacity and range, the fearful inventions for the destruction of cities and fleets, the deadly bomb—all tend to make modern war an almost unthinkable horror.

This greatly multiplied destroying power of military weapons, by means of which hundreds of men may be mown down like grain with a single shot, might well lead one to question the advantages of such an outcome of modern inventive genius did not their very terribleness contain in itself the reason for their own annihilation. Such wholesale slaughter of human beings cannot but be revolting to the modern humane sentiment, to the higher regard for human life which a higher civilization has inculcated. Face to face with the horrible desolation which these engines of war carry in their wake, nations can scarcely fail to hesitate before rashly precipitating a war which must result in such wholesale slaughter. The present tendency toward arbitration in the settlement of international difficulties rather than the rushing headlong into war on any trivial provocation is no doubt due largely to this greatly augmented killing capacity of latter-day implements of warfare. These very triumphs of human inventive genius, which seem to menace the peace of the world, may themselves greatly hasten the day when

> "The war-drum throbs no longer, and the battle-flags are furled
> In the parliament of peace, the federation of the world."

## BANKS AND EXCHANGES.

THE business of banking is an extremely old one, or, more correctly speaking, some of the functions of banks have been exercised from earliest historic times. In the republics of Greece and Rome there were persons who received money on deposit, paid it out on presentation of drafts drawn by their clients, and derived their profits from investment of this money. The origin of what might properly be termed a banking system dates, however, from the establishment of the bank of Venice, in the year 1171.

This bank owed its existence to the wars with both Eastern and Western Europe, which had brought great disorder into the financial condition of Venice. To obtain means for carrying on these wars, the government was led to order, as a war measure, a forced loan of one per cent. from every citizen, upon which loan the State promised to pay an interest of five per cent. To conduct the business consequent upon this transaction, a body of commissioners was appointed who should issue to the citizens stock certificates for the sums paid by them. These certificates might be sold or transferred at will. The Italian word for denominating this loan was "monte vecchio;" but as the Germans at that time possessed the mastery of a great part of Italy, the German word "bank" came also to be applied in common usage. The

bank of Venice was thus the origin of the funding system, or the system of public debts. It was not until several centuries after its establishment that it began to transact what is now called banking business. This bank continued in operation until the overthrow of the republic, in 1797, by the revolutionary army of France.

The function of these earliest banks was mainly "financiering;" their purpose to float loans for the government. The banks of Venice, Amsterdam, Hamburg, and others were founded on what is now called the currency principle. This principle is, in brief, that a bank should in no case issue notes greater in amount than the specie which it has in reserve, it being claimed by the advocates of this principle that any extension of a bank's credit beyond this limit must result in a depreciation of the currency.

The second function to be historically developed by the banks was the returning to the people good money in place of clipped and diversified coins. The cities of Venice, Hamburg, and Amsterdam being the centres of an extensive foreign commerce, large quantities of foreign coins, often mutilated and debased in value, naturally flowed into the money circulation. To obviate the inconvenience caused by this multiform and uncertain currency, banks of deposit were established by the authorities in each of these cities, the first being at Amsterdam, which should receive both foreign coin and the light and worn coins of the country, at their intrinsic value in the standard money of the country, making only a slight deduction for defraying the expense of coinage and the necessary expenses of management. For the moneys received, the banks gave to the depositors credit in the form of notes, or by an entry in their books.

These bank credits assured a uniform standard of payment, and laws were enacted requiring all bills above a certain amount upon these cities to be paid in these credits, to which the name of bank money was given. These, being always exchangeable for good money, came naturally to be at a premium, as compared with the clipped and debased coins forming the current money, this premium being sometimes as high as nine per cent. It must be observed that these credits of the Amsterdam and other banks, while called "bank money," were widely different from the bank money of our day. In the first place, they did not circulate from hand to hand as mediums of exchange, and, secondly, they were never issued in excess of the metallic money in the vaults of the banks.

Banks such as these have never had an existence in England or America. The banking system of England had its origin during the civil war, in 1697. The goldsmiths of London began to receive the gold of merchants on deposit, promising to repay it on demand, with interest at six per cent. for the use of it. In exchange for the money received the goldsmiths issued to their depositors credits to an equal amount. To enable them to do this, they were obliged to invest the money so that it should return them a profit. They discovered that, in order to meet the demands upon them by depositors, it was not necessary to keep on hand specie to the full amount; that, in fact, under ordinary circumstances, about one-tenth that sum was sufficient, since, while part of their customers might on a certain day choose to present their credits and demand their money, a corresponding number were equally likely to pay in coin equivalent in value to that paid out. They therefore invested the surplus funds in their

possession by buying commercial debts, or bills of exchange, which, being payable in two or three months, soon returned them a profit on their investments. These bills were bought not always with actual cash in their hands, but sometimes by giving in return for them promissory notes.

The bankers continued till about the year 1772 to issue promissory notes payable to bearer on demand. About this time they introduced a new method of purchasing bills. When they received bills from their customers to discount, the bankers would give them in place of promissory notes, a credit equal to the value of the bill, on their books, and would issue to the creditors printed forms which were called checks, which were bills of exchange payable to bearer on demand. These checks were put in circulation like bank-notes, and a banker was forced to pay a customer's checks to the extent of the money deposited. The modern system of banking by means of checks is the same in principle as that in which bank-notes are issued, the difference being one of form only. The bank-notes were on the face of them obligations of the banker to pay the money named, while checks are not direct obligations of the banker. For this reason when checks are transferred from one person to another the transferrer is usually required to indorse them. Bank-notes usually pass with no indorsement.

Of the famous banks whose history forms a part of the history of the country in which they are established, the Bank of England is perhaps the most noted. This bank, like that of Venice, grew out of necessity for government aid in time of financial depression. In 1694, during the reign of William and Mary, the war with France compelled England to devise some new means of meeting the heavy debt which

the military expenses were constantly augmenting. The idea occurred to William Patterson that the government, which had been paying from twenty to forty per cent. interest on loans, would grant almost unlimited privileges to an institution which should advance it money at reasonable rates. Following out his suggestions a bill was finally carried by the government for the foundation of a Bank of England. Within ten days after the books were open for subscriptions, so popular was the idea with the people that the entire sum required, one million two hundred thousand pounds, was subscribed.

The bank was opened for business on January 1st, 1695, the subscribers being incorporated into a company denominated "The Governor and Company of the Bank of England." The charter was granted for eleven years, but this was extended in 1697. This bank discounted bills of exchange at from three to six per cent. The management of the entire public debt of England was placed in the hands of this bank, for which service it received compensation from time to time. It paid also certain pensions and annuities.

After the close of the Revolutionary War the country entered upon a period of great commercial and industrial prosperity. As is customary at such times, people invested recklessly and multiplied their obligations beyond all possibility of fulfillment. The number of banks increased rapidly in England, and the result of the undue inflation of prices and credits was a commercial panic; exchanges turned against England, and the pressure on the bank was such that in 1797 it was compelled to suspend specie payments. This was regarded at the time as a temporary measure, but the bank did not resume the payment of specie until May of the

year 1823. Resumption was at that time accomplished only with widespread disaster to the commercial world, which could not but be affected by the calling in by England of so large an amount of gold as would enable the bank to resume.

By the bank charter act of 1844, the Bank of England was prohibited from issuing notes beyond a certain limit without an equal deposit of gold. The operation of this law has been, however, three times suspended, the last occasion being in 1866, when the rate of discount was raised by the bank to ten per cent.

During the war of the Revolution in the United States the country was extremely poor, quite destitute of the precious metals. The government experienced great difficulty in getting funds to carry on the war. Congress in 1775 attempted to meet this exigency by an issue of two million dollars of paper money, but these issues soon depreciated until they became valueless.

In 1781, Robert Morris, the celebrated financier of Pennsylvania, submitted to Congress a plan of a national bank. The provisions for this bank, as outlined by him, were that it should have a capital of four hundred thousand dollars in shares of four hundred dollars each, and should be under the management of twelve directors. On December 31st an ordinance passed Congress for the incorporation of this bank, and it commenced business in 1782. Of the capital of four hundred thousand dollars required, two hundred and fifty-four thousand dollars had been subscribed by the government. The first president of the bank was Thomas Willing. This bank became an important auxiliary in aid of the finances of the government, and continued to render valuable assist-

ance until the close of the war. This institution was also incorporated by the State of Pennsylvania on April 18th, 1782. Owing to some disagreement between the government of Pennsylvania and the bank in 1785, the State repealed the charter, but the bank continued under the charter of the central government. In 1787, the bank was rechartered by Pennsylvania, and the charter has been from time to time extended.

On the organization of the government of the United States, Alexander Hamilton, then Secretary of the Treasury, in his report on finances urged upon Congress the importance of establishing a bank of the United States. This proposal of Hamilton's met with opposition in Congress, but it finally passed the House in February, 1791, having previously passed the Senate. The capital of this bank was ten million dollars, to be divided into twenty-five thousand shares of four hundred dollars each. The subscribers were incorporated as "The President, Directors, and Company of the Bank of the United States." Subscriptions, except those of the United States, were payable one-fourth in gold and silver, and the remaining three-fourths in six per cent. stocks of the United States. The bank was chartered until March 4th, 1811. It was authorized to hold property of all kinds to the amount of fifteen million dollars, and was to be under the control of a board of twenty-five directors, who should choose the other officers of the bank.

This bank was established at Philadelphia, with branches at different points. In 1808, application was made to Congress for a renewal of the charter. Mr. Galatin, the distinguished financier, at that time at the head of the treasury department, reported to Congress a memorial in favor of

such renewal. Mr. Galatin suggested changes in a new act of incorporation, giving sound and excellent reasons for the re-incorporation of the bank. The bill was defeated on February 20th, 1811, by the casting vote of Vice-President Clinton. The bank was therefore obliged to close up its business.

The second bank of the United States was established in 1816. During the war of 1812–15, the government had found itself repeatedly embarrassed for want of money, and had frequently had recourse to the banks for aid. On the recommendation of Alexander Dallas, Secretary of the Treasury, a bill passed Congress providing for the establishment of a bank, the charter of which was to extend to March, 1836. The capital of the bank was to be thirty-five million dollars. In 1836, the bank ceased to act under the charter of the United States, but continued, with the same capital, under a charter of the State of Pennsylvania. In 1839, the bank was compelled to suspend specie payments. It resumed payments in January, 1840, to finally suspend in February of the same year.

Prior to the passage by Congress, in 1864, of an act "to provide a national currency," there were many State banks in operation in all the States. These banks received their charters from the States, and there were of these State banks, in 1856–57, no fewer than fourteen hundred. The over-issues of many of these banks, combined with the uncertainty which must naturally arise from so many sources of issue, had led to a disordered condition of the currency. The public had, indeed, by the experience of several serious financial crises, been educated to somewhat sounder views on the subject of money, and a wiser understanding of the princi-

ples underlying a safe banking system, but much still remained to be done before a perfected currency should be secured.

The emergencies of the Civil War led to the initiation by Secretary Chase of a movement which resulted in the establishment of the present banking system of the United States. This system was modeled on that inaugurated in New York in 1838, all notes being secured by an abundant deposit at the Treasury Department in Washington of United States stocks. The Treasury was to sell to the banks United States bonds as the basis for their note circulations, and all notes of State banks were to be taxed ten per cent., which soon drove them out of circulation. As a war measure, the national bank law was not a great success, as the bank did not become fully established before the war was nearly at an end. But it resulted in placing the currency of the country on a more secure basis than had been before accomplished. By this new law the Comptroller of the Currency, whose office was then created, was authorized to permit the establishment of banking associations, of not less than five persons, for periods not exceeding twenty years, with a minimum capital, except in small places, of one hundred thousand dollars. Such associations were required to deposit with the Treasury Department United States bonds to the extent of not less than one-third of their capital, the Treasury in turn issuing to them circulating notes in amount equal to ninety per cent. of their bonds.

The profit to the banks under the present system depends upon the rate of interest on the bonds themselves, and the premium or discount which the bonds may be at any given time purchased. The gradual decline and final disappear-

ance of the premium on gold, the reduction of the rate of interest on government bonds, and the high premiums upon bonds bearing the reduced rates of interest have all combined to reduce the profits of the banks. The proportion of bank-notes is, from this reduction in the profits of bank-note circulation, steadily diminishing. This fact may, unless some change in the financial system be brought about, cause the country to forego, in time, the great advantages of the present banking system.

Differing from bank-notes, yet like them a species of credit, are bills of exchange, which play a very important part in modern commercial transactions. A bill of exchange is an order from one person to another to pay a certain sum of money. It differs from a promissory note, in that the one is a promise, the other an order to pay something. The mode of paying and of receiving payment for goods from one country to another is by bills of exchange. By this means is obviated the expensive and inconvenient necessity of shipping the precious metals from country to country in payment for commodities. Bills of exchange originated in Italy during the twelfth century. The first function performed by them was payment of the taxes levied by the Pope on the Florentines. It became the custom of the agents of the Pope to send drafts on their principals to the Pope in payment for taxes collected. A bill of exchange was thus originally a banker's draft addressed to an inhabitant of one country from one of another. The oldest bill of exchange known was dated 1380. It is a matter of some doubt just when the idea of negotiating bills of exchange was introduced. Some writers claim this innovation for Cardinal Richelieu, but this has been disputed.

"Exchange," in the language of merchants, means the

power which the money of one country has of purchasing the money of other countries. Exchange is at par when for a certain amount of money—metal, or its equivalent—you can buy a right to receive an equal amount of the same metal in another country. Exchange is above or below par when the right to receive a given amount of metallic money in another place must be purchased by paying a greater or less amount of the same metal in the place where the purchase is consummated. Exchange is at par when the payments from one place to another or from one country to another exactly balance each other. When this is not the case exchange is said to be against the country having the greater sum of payments to make. The premium on bills cannot rise higher than the cost of shipping the precious metals, since, rather than pay a higher price for a bill, the merchant would prefer to ship the gold in payment for goods.

Credit has become in the modern world a most powerful agent in the transactions of commercial affairs. It is indispensable in rendering the entire capital of a country productive by transferring capital from hands in which it would lie idle, or be wasted or destroyed, to those in which it would be employed in productive enterprises. By means of credit, capital may be made available for turning to better account all the industrial talent of a community. Credit is purchasing power just the same as money, and an increase of credit in a country has therefore the same effect as would be produced by adding to the amount of metallic money in circulation. The superiority of bank money as a convenient medium of exchange is evidenced by its wide adoption at the present day by all civilized countries.

But while credit has power, it has not, as some imagine, magical power. Lost in admiration of the harmonious work-

ings of the present highly perfected system of banking, many persons are led to believe in the feasibility of a still greater extension of its functions. Since credit fills so large a place in the financial world, may it not assume a still wider power? May it not, in fact, usurp the place of money altogether? Inasmuch as a promise to pay money circulates as freely side by side with money, why not dispense with money in its metallic form, and, as credits are more easily created, let nations become wealthy by multiplying them indefinitely?

The flaw in this reasoning is the neglect to take account of the thing that gives to credit its value, the fact that it has back of it the ability to fulfill the promise of which it is the representative. A promise may never be kept, there may be no probability that it will ever be called upon for a fulfillment. But there is yet a latent quality in the human mind which leads it to demand that a promise shall be possible of realization. The schemes for issuing irredeemable notes, which have in different countries and at various times been attempted, have proved that there is a limit to the extension of credit beyond which the prudent financial intuition of a people will not suffer it to go.

If the banking functions are to be extended, such expansion must take place on lines of sound principles of money and credit. And the vastly diverging opinions of the thinkers on these subjects would warn against hasty conclusions where they are fraught with so weighty consequences. A safe and judiciously managed system of banking is the most powerful factor in enhancing the material prosperity of a country, while rashly and unwisely conducted it may become rather the means of undermining the foundations of national security and welfare.

## MECHANISM IN ART.

THE evolution of the human mind through the ages, the changes in thought and opinion which "the long results of time" have brought about, are none the less astounding than the modifications which the Darwinites would have us believe have been brought about in the human form and features. Human history is but one long narration of change, progression, of shifting views and feelings. To-day a race, a class, a sect, are scorned, despised; to-morrow the nations haste to do them honor, the past is ignored, "and the multitude make virtue of the faith they had denied."

The student of to-day reads the history of the past with an ever-growing amazement at the social ideas of caste and condition, which were clung to with a religious tenacity by the ancients. It demands all the different conditions and environment which the existence of a slave class creates in a community to enable one to enter into and interpret the feeling which the nations of antiquity had toward any form of manual exertion or the individuals performing it.

Society has, in all ages, idolized, bowed down to, the painter, the musician, the sculptor. Nations have enrolled their names high among the lists of their great and honored. It was not to be wondered at that a people like the Greeks, whose reigning passion was a love for the beautiful, whether in the human

face and form or in painting, sculpture, and architecture, should hold in light esteem the less elegant although equally worthy arts. In them the æsthetic was cultivated to the exclusion of everything else. "The glory that was Greece" came from this love for, this worship of, the beautiful in all things. And so the world has been ever since admiring and revering their thoughts of beauty, which, imprisoned in marble or reflected on canvas, have lived to tell to the ages what great and lofty souls inspired with true love for their art may accomplish.

But the Greeks failed to see that while the beautiful is truly useful it is not the only utility. And so the Greek nation perished, because they scorned what Irving has called "the coarser plants of daily necessity." The builders of the cities, the men who planned the walks and constructed the bridges, the inventors, the artificers, were the great unknown of history. The place of the artisan in the society of the old world would be difficult to define, because, forsooth, the artisan was not included in the social *régime* of the ancient time. He composed part of the great substantial foundation structure on which society rested, but he could hardly be said to have a social existence, as we now use the term.

The arts were classified by the ancients under two heads, as is done in modern time, but their very nomenclature of these two classes respectively reveals the different attitude occupied toward them from that of the present. The early classification was into the *liberal* and the *servile* arts. In the first class, the liberal arts, which, as the name liberal, from Latin *liber*, free, implies, were those practiced by free men, were included painting, music, sculpture, poetry, and oratory. They were the same professions as those which, at

the present day, are denominated the fine or liberal arts. The second class, the servile arts, were those which were deemed fit occupations only for slaves. This class embraced all of what are now called mechanical pursuits and also the useful arts. This latter term is equally a misnomer, in that it ignores the true usefulness of all in poetry, music, or painting that ministers to man's mental or spiritual being, and lifts him above mere animal existence.

All of these mechanical arts were, by the Greeks, relegated to the hands of slaves. It would have been thought a degradation for a freeman to perform such tasks. Agriculture alone was held a worthy calling for a free Greek citizen. There may be, perhaps, a lingering trace of this idea in the physiocratic views of a later day that agriculture alone was productive labor. The Greeks, indeed, held trade in little favor. It was a part of their policy of exclusiveness to eschew commercial relations with other nations. And it is to commerce and a large interchange of commodities that the industrial arts must owe their greatest prosperity. Among nations famous for their commercial activity we find even at that early day a quite different attitude toward the mechanical arts. We find them held in high regard by the natives of Tyre and Sidon and by the Phœnicians. This is not difficult to understand, since the works of the artificers were in these great trading countries the foundation of the national wealth.

Turning to ancient Rome, we find much the same state of things as in Greece. The fine or liberal arts alone were deemed a worthy employment for a Roman citizen. The mechanical arts were left to be practiced entirely by the slave population, and the artisans in Rome were a degraded class, the lowest stratum of the social structure. Even so great a

mind as that of Cicero's shared the national scorn for any form of manual labor. "All artisans," he said, "are engaged in a sordid employment, nor can anything ingenious come out of a workshop." Down to so late a period as during the reign of the Emperor Charlemagne, we find the industrial arts still left to the serfs.

Shortly after Charlemagne's time, however, we discover the mechanic gradually coming to a position of higher repute in the community. It began to be a not altogether unheard-of thing for a free citizen to employ himself in one of the once-degraded professions. About this time, too, it became customary for the monks to beguile the monotony of their leisure hours, formerly devoted almost exclusively to the weary copying of manuscript, to the practice of some one of the useful arts. The tenth century witnessed a marked change in the condition and estimation of the artisan. It is related that at Vicenza, in Italy, a criminal could actually escape the death penalty by calling to his relief a Roman law, which decreed that a prisoner might for a first offense be pardoned, if he could prove himself to be exceptionally skilled in any useful art. About the tenth century guilds and societies of artisans began to be formed, by becoming a member of which the artisan enjoyed certain privileges and advantages.

The Hebrew nation was peculiar for the esteem in which the industrial arts were from earliest times held by them. In one of the books of Moses we find mention of one skilled in manual arts, and thus skill, far from being despised, was looked upon as divine in its origin. The second King of Judea, in seeking workmen to build his temple, was compelled to appeal to a Phœnician prince to send him workmen, since, he said, the Sidonians were known to be skilled above

all other peoples. We find in all the writings of the Hebrews, most respectful reference to the useful arts. Parents were counseled to teach their children a trade, the Jews holding that manual skill was no detriment to mental advancement. This feature of the Jewish people was adhered to by William Penn in the code of conditional laws drawn up by him for the government of Pennsylvania and Delaware. The code contained a statute to the effect that all children who had reached the age of twelve years should be taught some useful trade, as an encouragement to industry in the poor, and as a safeguard for the wealthy, in case they should become dispossessed of their property.

The disdain with which most of the early nations regarded the whole subject of mechanics, has resulted in great loss to the modern world as well. It is known that there were produced occasional inventions of great importance in those ages, of machines for moving large bodies, and for performing other mechanical services, but the neglect of the learned to turn their attention to such subjects, and the slight popular estimate of their importance, suffered not only the names of the artisans, the inventors, to perish, but even all knowledge of the valuable processes to be buried with their time. The successive steps in the invention of machines were never recorded, but one work of importance, a treatise prepared by Vitrivius on architecture, during the reign of Augustus, containing any information of value on such matters. How the vast blocks of stone, of which the pyramids and other massive structures of antiquity were composed, were raised to so great height; what was the nature of the powerful mechanical invention which could perform such gigantic feats are secrets which no ancient documents disclose.

Archimedes, it is true, developed some theories in regard to mechanical laws which were far in advance of the notions of his time—so far, indeed, that it was centuries before his doctrines gained anything like general acceptance. But the difficulties encountered by the ancient philosophers in applying to practical purposes the theories which their brains had conceived, lay in the inefficiency and lack of skill of the classes to whom the practice of the mechanical arts was relegated. These arts being left to the hands of a slave population, suffered naturally the stagnation which characterizes all industries exclusively the occupation of serfs. Slave labor is always found less intelligent, less capable of development, than the labor of free workmen, and the art which depends for its existence upon the exertions of a servile class will ever be found slow of advancement. The great ideas concerning the action of the physical forces of the universe, which the great minds of the time worked out by long and arduous processes of thought, failed of the fruits of good which they should have borne to the world, because there were lacking the skilled hands, the ingenious workmanship which must supply the machinery needed to reduce them to practical application.

It is not to be wondered at, therefore, considering the esteem in which the useful arts were held, that so many centuries should pass without any observable progress being made in them. Men were content to go on in the same beaten track that their fathers had trod, ploughing their fields with the same implements, spinning their flax and wool in the same primitive manner that their ancestors for hundreds of years had done before them. It was scarcely worth any one's while to turn his thoughts to the invention of better ways of

doing. Labor-saving devices concerned the upper classes but little, since the labor economized would be at the most slave labor, and the artisan class occupied themselves too degraded a position for any great creative work to be looked for from them.

The Baconian philosophy did much to disentangle men's minds from the confusions of abstruse metaphysical speculations, and turn their thoughts toward those useful arts which were essential to the bettering of human condition in the realm of material things. James I of England extended great patronage to the mechanical arts, and during the reign of that sovereign considerable progress was made. It opened up an era of hopefulness for the artisan, when the invention of the great machines used in the textile and other industries, made possible the accomplishment by machinery of much that had formerly to be produced by slow and laborious hand labor. Machinery revolutionized the industrial, it brought temporary hardship and deprivation to many artisan classes, but it brought in the long run a better condition to the laborer. The minute division of labor, which prevails in the modern industrial world, may indeed impart monotony of labor to the workman condemned to the endless repetition of a single unvarying task. But, after all, monotony of work is not so bad as monotony of life. The shorter hours for labor which the introduction of machinery brought about have given the laborer greater leisure and opportunity for improving his condition than he before had. So well have such opportunities been improved that the great inventions of later years have been mainly the outcome of the genius of the artisan class.

It has remained for these later days to place the mechanic

arts in their proper rank, as of equal dignity and value with the fine arts, and with this higher estimate of the useful arts, has come a truer appreciation of the individuals whose lives are given to the practice of the mechanical professions. The great and famous men, who have by their inherent talents risen from the ranks of mechanics to positions of prominence and honor, would of itself cast eternal discredit on the ancient theory that such labor had in it that which must necessarily degrade the mind. The modern world, instead, crowns with honor the successful inventor. Wealth, to-day, showers with bounteous hand her treasures upon the man who has accomplished some mechanical triumph.

And after all, do we not mistake in denominating as purely mechanical the work of the shop, the task of the machinist? It has been said of the fine arts that they are those in which the mind has more to do in production than has the hand, while the mechanical arts are more the product of the hand than of the brain. But what industrial art is wholly mechanical? It has been well said that the man who first invented even the rudest tool was an artist. He must have had imagination, design, the power to reason and deduce conclusions. There was in the production of that simple implement far greater exercise of mind than of muscle. And the same is true in practice as in invention. We watch a man tending a highly complex machine. His action looks to the careless observer a simply mechanical task. There seems in the one thing which he is required to do over and over again, no call for mental exertion, no demand upon the higher faculties. And yet to fit that man to do that work, to properly train his mind up to the point of rightly tending that intricate piece of mechanism, has required centuries of

education and development. The ignorant savage could no more perform such a feat than he could write a poem or paint a picture. The power of mental application, the self-control, the adaptation in his thought of the means to the end would be found wholly lacking in him. He would possess the muscular strength requisite for its performance in a greater degree perhaps than the civilized artisan, but the intellectual training, that cleverness and dexterity which are the slow growth of generations of civilizing agencies, would place a wide distance between the skilled workman and the savage. And going thus through the entire list of the mechanical professions, we might well find it difficult to discover one to which this test applied would not reveal that it was more or less the product of the mental faculties.

With the study of the physical forces of the universe, and their application to the many different devices which minister to human needs and pleasures, has come a great enlargement of man's mental horizon. "Material progress," says E. C. Stedman, "determines the intellectual and spiritual progress of the human race." And not a science of to-day but what owes an overwhelming debt of gratitude to the inventions and skilled workmanship of the artisan classes. The wonders of the heavens are more clearly and marvelously revealed to man because of the exquisitely ground lenses of the telescope, and the ingenious machinery in which they are fixed. The human intellect is quickened and expanded with the rapid interchange of thought made possible by the printing press, the telegraph, and the steam engine.

The world is coming to know that men cannot separate one art or class of arts from the others, and pursue them to the neglect and exclusion of all else, but that there is a close

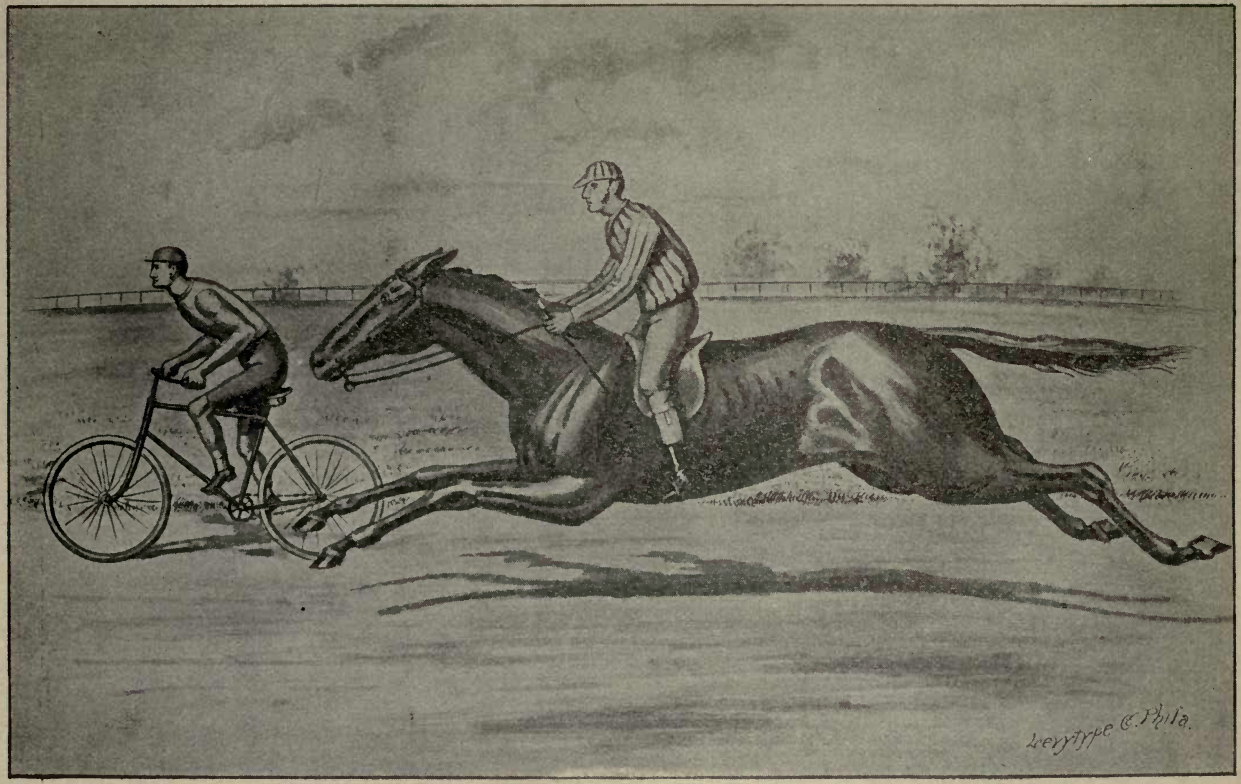
interdependence of all arts and industries, as well as of all classes of society, the one upon the other. That nation which scorns the useful, the practical, and cultivates the beautiful alone, declines and falls because it had a one-sided, an unnatural development. It is only by a true recognition of the harmonious connection existing between all the arts, by a wise utilization of all the forces in the world, that the unity, the completeness, the fullness of national life is attained.

## BICYCLES AND CYCLING.

THE early stages of the development of the bicycle seem to be involved in obscurity. The idea of self-propulsion by means of wheels must, undoubtedly, have arisen from the habit to which Young America is still addicted, that of sitting in a hand-cart and shoving along, by using the feet, in places where the slope will not allow the cart to go without assistance. At first, experiments were made with four, three, and two wheels. It is said that one wheel was also tried, but abandoned as not practical for general use. But, even to-day, some excellent trick-riding is done on an ordinary carriage wheel without gearing or appliances of any sort.

The first of which we find an account, but no description, is said to have been invented by one Richard Lovell Edgeworth, about 1767.

Soon after the great continental war, in 1815, the first bicycle was introduced into England from France. It is described as being a primitive, awkward affair, having a couple of heavy wooden wheels of equal diameter, of the size of carriage wheels, and joined by a longitudinal wooden bar, on which the rider's seat was fixed. The wheels were placed one behind the other. This machine was propelled by pushing the feet against the ground. For about fifty years all the




A CONTEST.

appliances used for self-propulsion were found to be too crude and unwieldy for general adoption, and the machines were only used spasmodically and for short times. In addition to the description given, these early machines had an arm-rest placed at the front part of them. In propelling this crude affair, the rider placed himself in the saddle or seat, astride the wooden beam, and with his arms on the rest pushed the "dandy-horse," as it was called, by kicking the ground on either side of him alternately with his feet. We are told that skillful riders, by so doing, were enabled to attain sufficient impetus to cause the machine to run for some distance unaided; but when the momentum was exhausted they would be obliged to begin pushing again.

In 1816 a "celerifere," or velocipede, was exhibited in the garden of Tivoli, Paris. This is the same machine which is supposed to have been introduced the following year into England by Baron von Drais, who was a resident of Mannheim on the Rhine. Velocipedes of three or more wheels had been in use in England long prior to this time, but this was the first vehicle which was known there as a bicycle. This had wheels of thirty inches in diameter. It was called, after the Baron, the Drais cycle. Following its introduction into England, Denis Johnson, in 1819, invented some improvements and called it "pedestrian curricle." This had an adjustable saddle, cushioned arm-rest, and handles, which were curved and arranged differently from those in previous use. It was called both "dandy-horse" and "hobby-horse." It was introduced into New York in 1819 and created a great furore. It was forty years afterward that an ingenious Frenchman devised the pedal attachment. On account of the undignified attitude the rider was compelled to assume in propelling these

early machines, they were the subjects of much ridicule and fell into disrepute. It is said that the satire of Cruikshank effectually killed the hobby-horse of 1818.

The making of the first practical bicycle, about 1846, is credited to Gavin Dalzell, a Scotch cooper, who lived at Lesmahagow, in Lanarkshire. It was called the "wooden-horse," on account of the material of which it was constructed. "The saddle was low, and the pedal movements, or 'stirrups,' which moved backward and forward alternately, were connected by iron rods with the cranked axle of the driving-wheel."

After a thorough trial of these new appliances, in 1867 cycling was revived. Prior to this date, however, M. Michaux, of Paris, had evolved from his fertile brain the idea of pedal attachments instead of stirrups to revolve the front or driving-wheel. The adoption of pedals involved the addition of the balancing-handle, by which the base of the machine could be changed as desired by turning the front wheel, even to a right angle, if necessary to balance the machine. This was called the bicycle, though generally known as the "bone-shaker," which is considered the more appropriate term, as it was made of wood, shod with iron tires, and without springs. The craze for cycling was at this time a serious one, affecting rich and poor alike, but the cost of the vehicles largely debarred the poorer classes from the pleasure. On account of the high price and difficulty of riding these machines, they fell into disuse, and cycling threatened to become a lost art. Another addition about this time or a little later, in 1869, is credited also to M. Michaux, who conceived the idea of making the front or driving-wheel much larger than the hind one. Soon after this date, M. Magee, also of Paris, largely

improved the machines by constructing them entirely of steel and iron. These have since been greatly improved by the addition of many modern devices and appliances; as, the application of crank action to the revolving axles, strong beaks to prevent excessive jostling, improvements in saddles and steering apparatus, and, greatest of all, the adoption of rubber for tires, which has proved the salvation of cycling. The identity of the English inventor of the rubber tire is not clearly established. These additions, together with suspension-wheels and steel framing, which have since been adopted, make the modern bicycle, and have rendered cycling a "joy beyond compare" to those who are so favored as to possess wheels. India rubber and steel have signal advantage over iron and wood in both strength and lightness, and the latest evolution of the bicycle, the "safety," combines all the expedients which have proven of practical value.

The use of the large wheeled bicycle debarred women and girls from riding the wheel. To obviate this difficulty, and to meet a great demand, the safety was manufactured. It was also thought to be a great assistance in learning to ride the large wheel. It has proven to be of such practical value in every direction that it has been generally adopted by both men and women. It being so much easier to mount, and danger from falls or headers being reduced to a minimum by its use, it has largely superseded the large cycle, or "ordinary."

The utility of the bicycle has been proven beyond all question of doubt. It has been demonstrated, times without number, that a person of average abilities can journey over from three to six times the space he could if walking, and with much less weariness. Three hundred miles have been

traversed in a single day, and the "iron steed" was as fresh as at first for three hundred more the next day. No rubbings, nor food, nor stiffened joints to be nursed back to their normal condition. It has been used in all departments of life, and been found of great service in them all. With it ministers visit their parishioners, doctors their patients, and business men find it a very satisfactory steed to ride to their offices and stores. It will not scare, shy, or balk; will stand quietly as long as desired; does not require to be harnessed and unharnessed, or bedded for the night, but altogether adapts itself to the requirements or wishes of its owner and rider. So generally is this state of affairs appreciated that many hundreds of thousands are in use.

The literature of cycling is abundant and varied, ranging from weeklies to annuals, to say nothing of the road-books and hand-books, without number. The first bicycling paper of which we have any knowledge was mainly a business paper or trade journal, by Cunningham, Heath & Co., of Boston, called the *American Bicycling Journal*. It should scarcely be called a bicycling paper, so much of its space being devoted to business. The first number of this paper was issued in December, 1877. The first real one, the *Bicycling World*, was founded in October, 1879. The first book was the *American Bicycler*, by Houghton, Mifflin & Co., published May, 1879. It has been well said that "1877 was daybreak, 1878 was morning twilight, and 1879 was sunrise for the revival of bicycling."

Prior to the final adoption of the bicycle as the popular means of self-locomotion, there had been numerous attempts to introduce a variety of tricycles and velocipedes, but all were discarded as altogether too cumbrous to meet the require-

ments. The same was true of all steam and electric contrivances and carriages. To this day nothing has been invented that will in any way compete with the safety bicycle for both sexes. There is no doubt that the cycle would have advanced much more rapidly than it has toward perfection had the skilled engineers and mechanics devoted their attention to the subject. But for many years it was only considered by them as the figment of an idle brain, and not likely to be anything but a toy. Hence their apathy. As soon as they turned their attention to it improvement went forward in mighty strides.

It has been found that persons with inbred love of athletics make the best riders of bicycles. Its use, however, should not be confined to these persons, for the therapeutics of the wheel are of inestimable value. It is a matter of doubt if there can be found a well-informed, intelligent physician who will say that the judicious use of the bicycle is injurious. The testimony to the contrary is overwhelming. Noted physicians everywhere are giving the weight of their influence in favor of cycling, and have also adopted the wheel in their own practice.

It is proven, beyond dispute, that for the head, heart, chest, back, and lungs—the upper and nobler parts of man—it is of incalculable benefit. All parts of the system are brought into play at the work of guiding, controlling, and balancing the machine. The arms, shoulders, and back feel the exercise more than the legs. In this exercise the circulation becomes active, the sluggish liver stirred up, the kidneys toned and strengthened, and the digestive functions improved and increased. The benefit to those of sedentary habits and occupations cannot be estimated. It will give them strength,

tone, and vigor throughout their entire system. One of its strongest points for them is that it requires them to be out in the sun and light and air.

It is nearly a century and a quarter since Blanchard and Magurer constructed their bulky contrivance to be propelled by the rider. It was described in *Le Journal de Paris*, July 27th, 1779. The bicycle proper is less than fifty years old, but velocipedes antedate that by a hundred years. The first occurrence of the name is found in the *English Patent Records*, in the provisional specifications of J. I. Starren, filed April 8th, 1869.

Pierre Lallement was the French mechanic who took off one of the rear wheels of a velocipede, set the other up to the middle of the axle, applied the foot cranks to the front axle, and thus made the first "bone-shaker." This was exhibited by his employer, M. Michaux, at the Paris exhibition of 1865. It was not patented, and Pierre Lallement came the following year to the United States, where, while looking for employment, he constructed a similar machine with two wheels, which he had brought over with him. He rode it in the streets of New Haven, Conn., causing much excitement. A Yankee, by the name of Carroll, induced him to take out a patent for the device in connection with himself, Carroll furnishing the requisite funds. This patent was secured November 20th, 1866. He called it a velocipede. It is described as being made of wooden wheels of nearly equal size, with iron tires, one before the other, and surmounted by a wooden perch. It was kept upright by means of the handles which turned the wheel in the direction in which it was inclined to fall.

The bicycle, which was first rightly entitled to the name was

that one introduced into England in 1869. Until the last five years the United States has not sustained the reputation of the American character for inventiveness, mechanical excellence, or progress and enterprise in this matter. In 1878 the Pope Manufacturing Company, of Boston, opened warerooms for the sale of imported bicycles. The outlook being promising, they began to manufacture them, and the Columbia was the first good American bicycle. It has proved an excellent and practical roadster. But it has only been since the adoption of the safety for general use that universal interest has been evoked.

There are clubs, associations, and leagues without number, but the most prominent of them all are the Cyclists' Touring Club, of England, which is also the oldest, and the League of American Wheelmen, of the United States. These are large bodies and wield an extensive influence.

B. W. Richardson, M. D., proves from his own experience that the bicycle has conferred on men and women "a new faculty of locomotion." He argues that beside developing physical strength, skill, courage, and endurance, it calls forth other powers; as the observation and scientific research in various lines. It generally, symmetrically, and thoroughly develops all the muscles and functions of the body. A man suffering from inguinal hernia has ridden sixty miles while he cannot walk five, and has also joined in long and hard runs and otherwise generally "kept up with the procession." This exercise is largely conducive to the formation and establishment of "a sound mind in a sound body." For nervous diseases of all kinds it is fraught with much benefit. If all of the weight rested on the pedals and was used in propelling the rider there would be no more energy expended

than in walking, but the truth is that two-thirds of the weight rests passively on the saddle while the remaining one-third is all that is needed to work. On good roads ten miles can be traversed sooner and easier than three can be walked. The moral tendency of the wheel is excellent, as no drunken person can maintain his equilibrium. It exhilarates the mind and is an enticing, fascinating exercise.

American bicycling dates from 1865, but had no actual foundation till 1878. A Frenchman rode one on the stage, performing astonishing feats of skill. The Hanlon Brothers saw it, obtained, improved, and helped to perfect bicycles. In 1877 about a dozen gentlemen rode wheels.

"Applied cycling" commands attention and careful trial by the people, as well as the approval of the right minded. The bicycle is a piece of machinery which is a great factor in recreation, for health giving, without which we are nothing, and for utility, which we almost worship. Some one has truly said, "Its use is inseparably connected with the acquisition of knowledge, beginning with mechanics and extending through physiology, climatology, topography, geography, natural history, and every other region of popular science."

England is working out the problem of military cycling, and her results are eminently successful. It is said to be claimed by those who have made the question a special study, who are military experts well acquainted with cyclists and their capabilities, that they can be made, at least, a very valuable supplementary screening aid, and in performing some duties have exceptional advantages. Their trained use of maps and intimate local geographical knowledge; rapidity of movement; powers of endurance, attack, and defense; to maintain a continuous front and of concentration: independ-

ence of supply of ammunition; indestructibility of means of locomotion; the capacity to be moved to certain points in sufficient numbers, and to take advantage of open railway communication, as wheels can be loaded on to cars in which horses could not possibly be transported. General Wolsely says: "The day will come, and is coming, when large bodies of cyclists will be recognized and become integral parts of every army in the field."

There is no doubt that its use will not be restricted to recreation and the military, but messenger boys, telegraph boys, mail carriers, and those in various avocations will adopt them as the speediest means of locomotion for short distances.

The objections to the use of bicycles are so slight and the advantages so great that its use at the present time has become well-nigh universal, and the owner of a wheel looks upon it as "a thing of beauty and a joy forever."

## ALUMINUM.

THE earliest whisper regarding aluminum dates back to 1807. But it is almost an unrecorded whisper, as even the name of the discoverer has not descended with it to the present time. For many years after this date the metal was only known as a laboratory curiosity, and not until about 1860 did it take its place among the regularly manufactured products of the world.

Aluminum is so common in nature that it is almost universal, and is literally trodden under foot. It is the metallic base of alumina, which is the characterizing constituent of the common clays. It also abounds in feldspar, slate, and many other rocks and minerals. Cryolite, a mineral first found in Ivigtuk, in Arksulfiord, on the west coast of Greenland, was the ore originally used for the manufacture of aluminum, but later beauxite, a mineral found at Beaux, in the south of France, was found to be rich in the metal, and was adopted as a more convenient source of supply.

The first authentic discovery of aluminum was by one Wöhler in 1827. He seems to have dropped the investigation for awhile, but in 1846 he again began his research, the result of which was the obtaining of minute globules or beads of the metal. This was done by heating a mixture of chloride of alumina and sodium.

In 1885, Deville, the French chemist, showed, as the result of several experiments, that aluminum could be prepared extensively, in compact shape, without great difficulty. He spoke of it as "the intermediate metal between the noble and the base metals." This was indeed true regarding the price, as well as in regard to the properties of it.

These early researches of Deville were begun in the laboratory of the Normal School of Paris, but afterward continued under the patronage of Emperor Napoleon III at the chemical works of Javel.

The use of beauxite for procuring aluminum is these early experiments was in this wise: The beauxite was heated with soda ash, producing the aluminate of soda, which was separated from the insoluble part by lixiviation, or leaching. Carbonic acid being then passed through the solution, pure alumina was precipitated. Balls were then formed by combining common salt and charcoal. These were put in an earthen-ware retort and heated while chlorine gas was passed through it. By this means there was a union of the charcoal and oxygen, and also of the chlorine and aluminum. This latter combination, being sublimed with common salt, was collected as a double chloride of aluminum and sodium. This combination being heated in a reverberatory furnace with metallic sodium and fluxes, the sodium absorbed the chlorine, thus setting the aluminum free, and it was thrown to the bottom where it could be collected and molded for use.

The manufacture of aluminum was not commenced in England until 1860, when Mr. I. L. Bell began it at Washington, near Newcastle-on-Tyne. The usefulness of the metal not being understood at this date, there was but slight demand for it, and it being an expensive process the works

there were shut down and France has stood unrivalled in its production until recently, when the Aluminum Crown Works were started at Hollywood, near Birmingham, England.

In America extensive works were started in Detroit, Mich., known as the American Aluminum Company's works.

The color of aluminum is white, resembling silver, having, however, a bluish hue, not unlike zinc. This color can be bleached in several ways: by the use of hydrofluoric and phosphoric acids, and by a heated solution of potash. While the color is sensibly that of silver, it looks whiter on account of the alloy in silver. The pure aluminum is perceptibly whiter than the commercial, for the latter is never pure, no matter how prepared. The chemically pure aluminum has no taste, but tastes like iron when it is strongly charged with silicon. It has no odor in its pure state, but also smells like iron when it is impure.

It is very light in weight, being four times lighter than silver and two and a half times heavier than water.

In elasticity it compares with silver and its tenacity is nearly equal to the same metal. It is one-third as strong as steel.

It is highly sonorous. A bar of the pure metal being suspended by a fine wire and struck emits a delightful sound, like a crystal bell. The greater the purity, the more sonorous. Hence, its availability for tuning forks. Attempts have been made to cast bells from it, but the result has not been entirely satisfactory, as the clappers seem to interfere with the free transmission of the sound, and they sound too much like a cracked pot. This sound emitted by the struck bar or ingot is found upon analysis to consist of two tones, A sharp and D sharp, which follow each other in rapid succession.

These tones are nearly synchronous, but the latter is more subdued.

Aluminum is a fixed metal, losing none of its weight by being violently heated in a forge fire in a carbon crucible, nor does it show the slightest tendency to volatilize at any temperature.

It is considered to be one of the best conductors of electricity, and the use of aluminum wire is strongly advocated for telegraphic purposes. It is thought to equal silver in this respect. Some scientists say that it conducts both heat and electricity even better than silver or copper.

Aluminum forms crystals when cooled slowly. These crystals are in the form of needles, crossing each other in every direction. Other forms have been reported, from time to time, but, upon investigation, they have proved to be incomplete, or only fragments of these longer crystals.

This metal is very ductile, as well as very malleable. The finest wire for art embroidery, and the thinnest leaves for gilding and decorating are made from it. In this, it equals gold and silver. In toughness it approaches iron, and is susceptible of a brilliant polish. It melts at one thousand two hundred and ninety-two degrees Fahrenheit, or seven hundred degrees Centigrade, and is thus cast into ingots for market.

By exposure to the air, whether dry or damp, it will neither oxidize or tarnish. The gases which so readily darken silver have no effect on this metal. Sulphurous vapors cannot tarnish it. Water and steam at a white heat affect it very feebly, acting only in spots.

The true solvent of this metal is hydrochloride acid, weak or concentrated, but when the metal is pure it acts slowly.

While aluminum does not withstand chemical agents in general as strongly as the noble metals, it does withstand air, sulphuric acid, nitric acid, and sulphuretted hydrogen, which iron, copper, and silver do not. For this reason, it makes an excellent substitute for these metals in many of their uses.

It is too soft in its pure state to endure much wear, or to keep a high polish, and too weak to support much strain; hence, the alloys of it which are made by combining it with other metals.

The ingots have a density of two and fifty-six one-hundredths, but when hammered and worked this density is increased to two and sixty-seven one-hundredths. It is, consequently, lighter than glass. On account of this lightness, it is used for various kinds of instruments: mechanical, optical, surgical, etc., etc.

In combination with other materials many useful compounds are formed. With copper, there are several alloys which are white, very hard and light, besides a yellow alloy, which is very similar to gold in color, though, of course, much lighter in weight. It is called aluminum bronze, consists of from five per cent. to ten per cent. of aluminum, and is very strong. This alloy was discovered by Dr. Percy, of London. For some time it was manufactured into watch chains, pencil-cases, and other small articles of ornament. More recently it is being made into table-plate, and is also used in carriage mountings. Its tensile strength can be made equal to steel, so it has been found available for field-guns. Its durability and anti-friction qualities cause it to possess great advantages for bearings of shafts.

An alloy with tin has been compounded and used for optical instruments.

"Tiers Argent" is the name of an alloy from which spoons and forks and small table-ware are made. This is a mixture of aluminum and silver. An alloy of five per cent. of silver is used for watch springs.

Although the history of aluminum is a short one, being only contemporaneous with the present generation, its general utility creates for it a most prominent place in the arts and sciences. It is being proven to be one of the most, if not the most, serviceable of the metals This is, of course, on account of its great tenacity, lightness, ductility, and malleability, as well as its non-corrosive qualities.

It is said: "From all the experiments which have been reported, and all the observations which have been made, we can conclude that aluminum has complete analogies with no one of the simple bodies which we consider metals."

What first engrossed the minds of the chemists experimenting for aluminum was how to extract it. They troubled themselves very little about the ultimate expense of the operation. A much cheaper process than any then in use was invented by H. Y. Castner, of New York, in 1886, which he patented in June of that year, and the subsequent year made his invention known. This was the first patent taken out on this process since 1808.

About 1760 Morveau called the substance obtained by calcining alum, alumina. Lavoisier was the first to suggest that the earths and alkalies had metallic bases. From this, alumina was suspected of being the oxide of a metal, and the metal was called aluminum. This was long before the separation of it was effected.

As has been intimated, 1807 is the first that we hear of any research into the preparation of aluminum. This at-

tempt was crowned with so little success that it seemed to merit but the slightest mention. Oerstedt, in 1824, believed that he had succeeded in extracting the metal, and published his method. But his successors in the work, using his directions, were unable to produce it. It was concluded that he had omitted a part of the operation.

In 1855, in the Palais de l'Industrie, was seen, for the first time, a large bar of this wonderful metal ticketed as "Silver from Clay."

In 1859, the first aluminum works were started in England, at Battersea, near London. There are no details given as to the size of the establishments or length of time they were in operation. It is believed, however, that they were ultimately merged into those of the Bell Brothers, at Newcastle-on-Tyne.

Since 1860 numerous patents have been issued and many inventions devised to facilitate its manufacture, and also looking to the reduction of its price. How effectively this has been accomplished will be shown by contrasting the price per pound in 1856, which was $90.90, with that in 1889, or $2.00.

The separation of aluminum by electrolysis was discovered accidentally and simultaneously by Deville, in France, and Bunsen, in Germany, in 1854. The battery method now usually employed is to run an electric current from a ten-cell battery through the double chloride. Carbon poles are used. Large globules of the metal collect at the negative pole, which, after being collected, are melted together into a compact mass under a layer of fused salt. The battery is also used in plating, for which aluminum is very superior. In combination with nickel, it makes a beautiful white plate which is far more durable than silver. It is itself capable of

being gilded and silvered in six different colors. Thus it can be readily seen how it practically excels either gold or silver.

During the last thirty-five years aluminum has been used in making medals, ornaments, furniture trimmings, culinary utensils, and many other small articles. The first article ever made from it was a baby's rattle for the Prince Imperial in 1856. At first there was much difficulty experienced in using the metal in its application to the mechanical arts, owing to the lack of a suitable solder, which would not be attacked by the acids with which the aluminum was cleaned. This is now obviated by the discovery of a solder composed of six per cent. of aluminum, four per cent. of copper, and ninety per cent. of zinc. Consequently, the use of the metal has become almost illimitable.

Aluminum is susceptible of a high polish, which is given it by dipping the polishing stone into an emulsion of equal weights of olive oil and rum and polishing the same as silver, though not with so heavy a pressure. The soiled surfaces are cleaned by dipping the article into benzine and drying in fine sawdust.

It can be stamped and pressed into any shape. The United States government, in 1865, experimented in making coins of this metal, but the results were not encouraging enough to ensure their adoption as currency.

Of the early work in manufacturing aluminum, it is said that prior to Wöhler, Davy had tried both the electrical and the vapor of potassium methods for separating the metal, but was not successful in his attempts. He could only secure a very impure article.

Aluminum leaf was first made by C. Falk & Co., of Vienna.

It is said that a very thin leaf will burn like paper when made into a roll. It burns with a brilliant white flame.

Aluminum resists the action of the graver's tool, as it slides over the surface as it would over glass. In order to engrave it, it has to be prepared with a varnish of four parts turpentine and one part stearic acid; or one of olive oil and rum, when it may be cut as easily as pure copper.

It is slow to melt because its specific heat is considerable and its latent heat seems to be very great.

There is no other metal so abundant or so widely scattered, but it is impossible to obtain it in a free state, as it is always in combination, nor can it be gotten by the ordinary methods of smelting, etc., as with other metals. Although so universal, it is a most curious fact that it is never found in the animal tissues, nor in plants, seeming to show that it is not necessary to their growth or development. Possibly it may be injurious to them. While aluminum is found everywhere in clay, until the adoption of recent methods the silica in the clay has rendered its extraction well-nigh impossible, at least at a figure that would create a market for it. Thus, for many years the manufacture of aluminum was greatly restricted. With the improved facilities of the present, the day is probably near its dawn which will see aluminum substituted for a majority of purposes in which other metals are now used. Housekeepers will demand their culinary utensils made of this metal because of its weight and its failure to oxidize and corrode. Ornamentation will demand its use on account of its great beauty and service. Its great adaptation to the mechanical arts has already been shown. Surgeons have found the use of suture wire of aluminum superior to any other. Dentists use it for plates for artificial teeth, as it

is light and no electric current is caused by taking other metals into the mouth. It will be likely to replace gold and silver because of its weight and cost, as well as its resistance of the action of gases and chemical agents. It will replace the common metals on account of its beauty and weight. It has been thought that aerial navigation would be reconstructed by its adoption. This is a little doubtful, as magnesium is nearly as strong and only seven-tenths as heavy. While it will not resist the elements as well, it may be easily protected so that it will.

Aluminum is not likely to be imitated or counterfeited, but some of its products undoubtedly will be. This will be especially true in the case of the gems of which it is the chief constituent. It occurs prominently in rubies, sapphires, garnets, topazes, to say nothing of the countless stones not deemed precious. Knowing the formulæ of their composition, it would be easy to imitate these gems, and cause them to become far more plentiful than the supply of Dame Nature.

It is very difficult to estimate the amount of aluminum manufactured since Deville first started the industry in 1854–56. The output of that time is placed at fifty-five pounds. In 1872 one firm, H. Merle & Co., issued four thousand pounds; another firm, the Bell Bros., one thousand six hundred and fifty pounds. Of course, this amount has been greatly augmented in these later years.

## EVOLUTION OF THE CABLE CAR.

FROM the olden time, "before the steam engine bullied the earth with thunderous stroke, and reduced space to a mere matter of time," the problem of "rapid transit" has vexed the minds of the people. Many solutions have been offered, both for individual and collective propulsion, which should be faster than walking. From the "bestridden walking-stick," as the velocipede or "hobby-horse" of Von Drais was dubbed, down to the present perfection of bicycles, cable and electric roads and steam moguls, many devices have been invented, only to be discarded, upon trial, as inadequate for the end in view.

When the railroad first began to run in the United States, the roads of the country were in a miserable condition, so the people most eagerly welcomed the rail traffic, merely stipulating that the engines should be detached in going through the towns, and horses substituted as the traction power. Subsequently, the engine was allowed to draw the train through city and town limits, but at a much slower pace, and latterly there has been the addition of a bell to be rung as a signal and warning to all in dangerous proximity to trains. From this changing from engine to horses the idea of the street railway was evolved. The very first car built to be drawn by horses was a rude log cabin, having seats along

each side, with a table in the centre of the room. Afterward, the coach or omnibus was adopted for many years.

The end aimed at in a street railway system is to concentrate the greatest power in the least possible space, not only in the turning of corners, but for economy of space in straight lines. It was formerly thought that only the steam engine could do this, but results have proved that the cable systems now in use can accomplish this purpose equally well, if not better, within the limits of their use.

The credit of originating a complete cable system does not belong to any single inventor. As with many other valuable discoveries of our time, the cable trains of to-day are the aggregation of numerous devices emanating from the brains of many scientific men.

The first cable lines were used to convey ores and coal from mines. These were simply overhead ropes, worked by means of pulleys, and were used in grades where animal power was not available. Their use proving their utility, they began to be more generally adopted, and their service extended to the carrying of passengers and freight. The first ore cars, or tubs, were suspended from a stationary rope by wheels or pulleys fixed along the centre of the top of the vehicle, and drawn by another rope. When they came to be adopted for carrying living freight or movables this running gear had to be doubled to secure equilibrium. Then the wheels are placed along each upper edge of the cars and two stationary and two traction ropes were employed. One of this kind was built at Gibraltar for the purpose of conveying men and stores from the town to the fortifications at the summit.

The idea of using wire cables for hauling vehicles is very

old, but secreting the rope beneath the surface is of recent origin. This was first called "underground haulage." Chains as well as ropes were employed in early experiments, but the use of them has been abandoned, as the ropes have proved far more practical. In the lines now in use the ends of the rope are joined, thus making the endless cable system, which possesses features of peculiar merit, as will be seen in the descriptions which follow. This plan was first practically adopted in connection with a street car line in the city of San Francisco, in 1873, with both mechanical and financial success. To the great enterprise and mechanical ingenuity of this City of the Golden Gate are due the origin and success of the modern cable system.

The first permit in San Francisco for a wire cable road was granted to General Abner Doubleday and Captain R. L. Ogden, of the army, who were the originators of the enterprise. The duties of the General calling him away from San Francisco, he sold his stock and interest to Mr. A. S. Hallidie, who studied, worked over, and perfected the system. It was ready for use in August, 1873. It has been found to be "adapted to all kinds of metropolitan railroading where the surface of the street has to be kept free from obstructions, where locomotive steam engines are not permitted, or where the grades of streets are so steep as to make the use of horses difficult or impossible." It is said that Mr. Hallidie was led to apply his patents to the street cars by seeing the poor, overloaded horses straining in climbing the steep grades, slipping, falling, and being dragged for some distance by the heavy loads attached to them.

This cable system is thus described: "An endless steel wire rope, three inches in circumference, eleven thousand

feet long, is stretched the whole distance, lying in iron tubes, supported every thirty-nine feet on eleven-inch sheaves. This rope is supported at every change of angle at the lower crossings on sheaves four feet in diameter, passing around a horizontal sheave eight feet in diameter at the lower end of the line, and at the engine house around two angle sheaves, each eight feet in diameter, which lead the rope on the grip pulleys, also eight feet in diameter, which are driven by one fourteen by twenty-eight engine. The steam is furnished by one boiler, sixteen feet by fifty-four inches, using three thousand seven hundred pounds of coal per day. They have also duplicate boiler and engine which are held in reserve.

"The patent grip pulleys being furnished at their circumference with jaws that grip and release the rope automatically by the pressure of the rope in the jaws prevent the rope from slipping, and being set in motion by the engine actuates the endless rope while traveling up one tube and down the other.

"In addition to the sheaves that support the rope in the tubes at the upper side of each crossing where the incline makes an angle upward there are sheaves in the tubes that keep the rope down and from striking the upper part of the tube.

"It will be understood that there is an opening in the upper side of the tube. This opening runs the entire length of each tube, forming a long slot five-eighths inch wide. This slot is not immediately over the centre of the tube, but on one side to keep sand and dirt from falling on the rope, to clear the upper sheaves, and to enable the foot of the gripping attachment to pass by and under the upper sheaves in the tube.

"The connection between the cars on the street and the traveling rope is made by means of this gripping attachment. The traction car or 'dummy' with the gripping attachment is attached to the passenger car firmly, so that there can be no danger of accident. The passenger car is amply provided with brakes. In addition to the usual car-brake there is another attachment operated in the same manner as ordinary brakes, which forces a broad band of wood down on each track immediately under the car. Strong iron drags are provided, so that if any accident should occur in going up the hill they will immediately catch in the street and prevent the car from going backward. When it is necessary to back down-hill these drags are raised up out of the way by the conductor.

"The 'dummy' is also provided with powerful brakes. The 'dummy' and cars are connected with a suitable coupling so that the weight of the car going down comes on the ropes, and is utilized to draw up the other cars on the other track. The brakes are not usually employed when coming down, except when it is necessary to stop, as the car runs down with the same speed as the rope, as long as the gripping attachment is in connection with the rope." The rope runs seventeen and a half hours per day, at a speed of six miles per hour. The road has a gauge of three feet six inches. An ordinary thirty-pound steel "T" rail is used, set flush with the surface of the street.

The first Cable Street Car line was run on Clay Street Hill Railway, but after three years of testing, when its economy and practicability had been thoroughly established, other lines were started in other parts of the city which have met with the same practical success

In 1876 Mr. George Sigl, the celebrated Viennese engineer, had a wire cable system running to the top of the "Mount Sofienalpe," one of the most delightful lookouts west of Vienna. It was about six hundred and fifty yards long from the end of Halter Valley to the summit. It exceeds all other roads in cheapness, simplicity, and small power needed to operate it. It is run by a twelve-horse power engine.

Col. W. H. Paine, in 1878, invented and patented an ingenious device for attaching the cars to the cable, which has been generally adopted. It is called the "rolling grip." It is so constructed as to allow the cars to start slowly and to gradually acquire the speed of the moving cable. He first invented this improvement for the mining cars at Solomon's Gap, at Wilkes-Barre, Pa.

There is no record of the adoption of the modern cable system by the Chinese, but in Hong Kong a sugar refinery has an aerial cable for the transfer of its products.

Cabling has progressed from the crudest forms till the present, when every feature of the system is covered with a multitude of patents to numerous persons. In England, over forty-five years ago, a patent was granted applying to certain parts of such a system, and while not exactly like those subsequently patented in the United States, there is sufficient similarity to show that the same principles are used by the modern railway cable lines.

Prior to 1850 even horse-cars had not been used in the United States, and it was not until they were proven to be successful here were they finally adopted in England. These will all be superseded, at no distant day, by more approved as well as economical means of transportation.

Before 1870, and directly after the obtaining of letters-

patent by E. S. Gardner, of Philadelphia, many skilled and scientific men gave their attention to the subject of cable traction. Some proposed that the cables should be raised on poles, especially for use on elevated roads, others that the cars themselves should be suspended, running from the top instead of from the base, as they now do, and many impracticable schemes were advanced. However, the elevation, or suspension, rather, of the cars was tried in the city of New York, on Greenwich Street, but after a thorough trial this method was abandoned, although it is said the principles were not at fault, but were not sufficiently well understood. Some believe that this plan will yet be applied to elevated roads with success, as its adoption will dispense with the heavy locomotives and motors now used.

Previous to 1872 Mr. Hallidie, of San Francisco, had studied the various methods of "carrying ropes" in vogue amongst the various mines of the country, and secured many patents for their improvement. The Clay Street Railway, before spoken of, was begun under his auspices in June, 1873, and opened to the public in August of the same year. His friends considered his scheme as purely visionary, and would not assist him in his effort. But, as is the history of so many such ventures, it succeeded in spite of opposition or derision, and through his energy and persistence cabling has become an assured success throughout the world.

In 1879 Robert Gillham, of Kansas City, turned his attention to the details of cable operation, but, like Mr. Hallidie, met with marked opposition. He, however, was enabled to secure the co-operation of Eastern capitalists who were willing and ready to aid him, not only with their money and influence, but with time and work as well. In Kansas City every

imaginable difficulty had to be met and overcome. Grades as steep as any in the country, high iron viaducts, and long spans as means of approach to the high bluffs, and tunnels passing under houses and streets, were some of the impediments in the way. But, in spite of all this, it is said that this system is the finest in the country. This road was completed in the spring of 1885. By it was demonstrated that right angles could be turned and excessive heights scaled.

In using the grip of the Kansas City cable, one of its jaws is directly under the cable and the other above it. The main shank or plates of the grip pass from these jaws through a slot three-fourths of an inch wide, located in the centre between the rails, at level of the street and which extends from one end of the road to the other in both tracks, connecting with the upper frame of the grip, where they are fastened to the operating levers. By throwing the grip lever forward, the upper part of the jaw closes upon the moving cable. When the gripman wishes to stop the train, he reverses the lever, when, by the use of a suitable brake attachment, the cars are brought to a standstill. There are two tracks having the car rails and the slot rails in position, which rest upon heavy cast-iron yokes or supports. The slot rails form the narrow slot through which the grip shank passes. The tube, or conduit, below the street is made from Portland cement concrete, laid around cores, which are removed when the cement has thoroughly set. At curves a series of vertical, conical-shaped curve pulleys are arranged, which are in continual motion while the cable is running. The cable itself is, in most cases, made of steel. It is usually of one and one-half inches in diameter, weighs two and one-half pounds per foot, and is made from six strands, of nineteen steel wires in each strand.

The Kansas City Cable Railway was the first duplicate cable railway built. If the cable is broken, there need be no cessation of travel, as is necessary with single line roads. Delays cannot occur, as there is a duplication of machinery throughout the entire length of the road. An interesting feature of this system is a little stationary steam engine, fixed to the bed-plates of the driving machinery, of power sufficient to move slowly either set of drums and cables without the aid of the additional weight of the cars gripping the cable. One set being thus in motion propelling cars on the street, the little engine is put in motion and the other cable moves slowly into the house, where it can be inspected and repaired as occasion requires. By this means the work of night inspection can be entirely done away with, as the cables cannot be properly inspected while propelling the cars, on account of the rapid motion. This duplication of machinery was an absolute necessity in Kansas City, because, in case of an accident, no horses could possibly be substituted to climb the grades.

While cabling was first used over grades too steep for the advantageous use of animal-power, the economy of its working has been so thoroughly demonstrated that it is being adopted in many of our large cities. It saves great wear and tear on streets. No one is shocked by overburdened, overworked, falling, and injured horses. It is estimated that the saving by the adoption of this system is from thirty to forty per cent. The usual rate of speed is from six to eight miles an hour. By its use steep grades are as accessible as level stretches. The trains are easily stopped and started. There are fewer cars required, because the increased speed admits of more trips being made. This system is not affected

by the weather, as will be shown later on. Not the least benefit to humanity by its use is the extirpation of the barbarous horse-car system, that "cruelty unworthy of humanity and civilization."

In 1881, Mr. C. B. Holmes, of Chicago, carefully investigated the results of the operation of cable roads, and concluded to apply the principle to the State Street and Wabash Avenue lines, which were under his control. To him belongs the credit of proving that this kind of traction was available under all kinds of weather and temperature. The mercury has dropped as low as twenty-nine degrees below zero, there has been two and a half feet of snow, and the frost has penetrated five and one-half feet into the ground without causing the loss of a single trip. The great advantages of this kind of traction has led to its introduction on both the west and north sides of Chicago, as well as the lengthy extension of the south side line. It has also been used and greatly extended in several other cities of the United States, in New Zealand, Australia, and other countries where extensive transportation is required.

Not until 1883, after being most thoroughly tested, and having stood the most crucial conditions, was it finally adopted in England. At this date a line was laid up Highgate Hill, London, which has been as successful as the American lines. Similar lines have since been constructed on other streets of that city.

The modern road, or tramway, as it was called, was first constructed and used in New York city in 1832, though not really introduced and adopted until later. In 1860 the first street railway was laid in England, in Birkenhead. Mr. George Francis Train was the inventor and designer.

During the next year the system obtained a temporary footing in the suburbs of London, but the roads were considered too much trouble, and the lines were soon removed. Eight years later an Act of Parliament was obtained for horse cars in Liverpool.

While the discussion of the adoption of the cable system in England was in progress it was thought that the erratic meteorological variations of the British climate would seriously interfere with its successful operation. But the adoption and trial of the plan in Chicago, where the most variable weather and greatest extremes of temperature were to be encountered, resulted in giving the measure the desired impetus to secure its adoption abroad.

In bringing the cabling systems to their present perfection the problem before the scientific engineers has been: "To devise and establish a mechanical system of locomotion that will afford the traveling public the same, if not better, comfort and accommodation than heretofore, and an equal degree of safety in transit at the same rate of fares. At the same time any such proposed scheme should show a distinct remunerative advantage to the shareholders and be reasonably free from the numerous objections raised by municipal or local authorities."

Among the principal cities of the world now using cable systems are: San Francisco, Chicago, Kansas City, Philadelphia, Pittsburgh, New York, Omaha, Denver, Sioux City, St. Paul, St. Louis, Los Angeles, Cincinnati, and Portland in the United States; London and Birmingham, England; Sydney, Australia; and Edinburgh, Scotland.

It has been found that electric and steam motors can accomplish no more than the cable, beside requiring such

heavy running gear and causing more noise and dirt by their employment. So cabling has passed beyond the age of experiment, and has now become a demonstrated fact and possibility.

In consideration of the approximate annihilation of both time and space as demonstrated in all kinds of methods for rapid transit, it may well be said:

> "Let those ride now who never rode before,
> And those who rode, now ride the more."

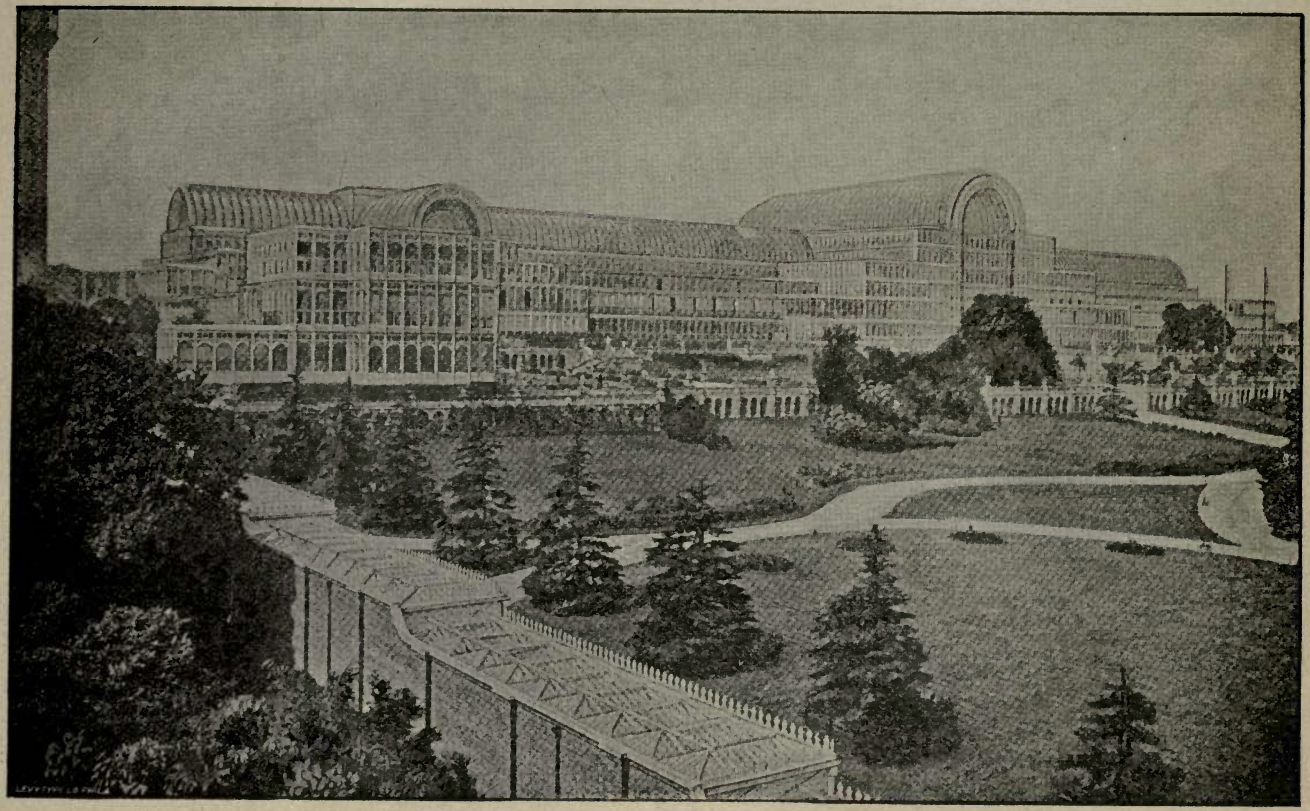
## THE PHONOGRAPH.

THE phonograph was invented in 1877. in experimenting with the telephone, in connection with the vibrating diaphragms of that instrument, Thomas Alva Edison discovered the principles and facts which led to the invention of this later machine. The primitive machines were first exhibited in 1878, both in England and America, since which time the instrument has risen above the rank of a lecture illustration and a philosophical toy, and has proven itself to be of immense value in many practical lines of work.

Previous to the success of Mr. Edison with the phonograph, there had been various attempts, by other parties, to construct talking machines, which resulted more or less successfully.

Chladni was the inventor of a method for rendering visible vibrations caused by a blow or any other impulse.

Professor Faber, of Vienna, built up an artificial organ of speech, the parts of which performed the same functions as the similar parts of our vocal organs. He solved the problem of a talking machine by reproducing the mechanical causes of vibrations making the voice and speech. Edison solved it by obtaining the mechanical effects of those vibrations. Faber reproduced the movements of our vocal organs, Edison the



CRYSTAL PALACE, LONDON.

motion of the drum skin of the ear when acted on by vibrations caused in using the vocal organs. In one way this "acoustical marvel of the century" is as simple as a coffee mill, but, scientifically, there are many subtile questions about it. By his invention Edison did for sound what Daguerre did for light, made it possible to secure and permanently retain the most fleeting impressions. With a vibrating plate, tinfoil, and a crank it became possible to arrest and fix all kinds of sounds, preserve them indefinitely, and reproduce them again upon demand, as they were at first received.

Professor Mayer, of Stevens Institute, Hoboken, N. J., made an acoustic apparatus, including several talking pipes. He could make them speak certain words quite distinctly by moving his hand on the top of them. Even short sentences were uttered. But none of these devices had the simplicity of a grindstone, as was claimed for the phonograph.

Another instrument was a small speaking trumpet, constructed by a Mr. W. H. Barlow. This was four inches long, with an ordinary mouthpiece joined to a tube one-half inch in diameter, the thin end of which widened out so as to form an opening two and one-quarter inches in diameter. This was covered with a membrane of gold-beater's skin, or thin gutta-percha. A spring, which held a marker, was made to press against the membrane with a slight pressure, to prevent, as far as possible, the effects of jarring and vibratory action.

But Edison's invention has far outstripped all others, and by it a new field may be opened in the arts and sciences. It is impossible to even conjecture the uses to which the wonderful instrument may be adapted. Time and necessity alone will determine. The use of the phonograph has resulted in the solidification and preservation indefinitely of something

more ethereal and impalpable than any gas—sound and thought; and by this has been realized one-half of the poet's aspiration:

> "O, for the touch of a vanished hand,
> And a sound of a voice that is still."

In this way voices that are hushed forever may yet speak to us. What a comfort this would be to many sorrowing ones.

It was the vibrations of the earlier forms of membranes of stretched gold-beater's skin having a small piece, or point, of iron attached to their centres, which led to the suggestion of the phonograph. In the first machines, as in the telephone, a stretched membrane received the vibrations of the waves of speech, but instead of communicating them to a similar membrane at the other end of the line they were recorded by means of a fine point on a cylinder covered with a sheet of tinfoil. Afterward a diaphragm of very flexible iron was substituted for the membrane, which in turn has been displaced and superseded by a diaphragm, or disc, of glass, to which is attached the cutting and reproducing styles.

The extraordinary acoustical discovery was that this bit of iron could reproduce all the peculiarities and variations of the atmospheric waves impinging upon the membrane when words were spoken within its range. Parafine paper was first used as the receiving medium, then tinfoil was tried, which has given way to a cylinder of wax that is now exclusively used in the machines.

The best idea of the machine will be gained by a description of one of the tinfoil instruments, noting afterward the important additions and improvements. This description will be given in nearly the inventor's own words:

The instrument is composed of three parts mainly; namely, a receiving, a recording, and a transmitting apparatus.

The receiving apparatus consists of a curved tube, one end of which is fitted with a mouthpiece. The other end is about two inches in diameter and is closed with a disc, or diaphragm, of exceedingly thin metal, capable of being thrust slightly outward, or vibrated, upon gentle pressure being applied to it from within the tubes. To the centre of this diaphragm (which is vertical) is fixed a small blunt steel pin, which shares the vibrating motion of the diaphragm. This arrangement is set on a table, and can be adjusted suitably with respect to the second part of the instrument—the recorder.

This recorder is a brass cylinder about four inches in length and four inches in diameter, cut with a continuous "V" groove from one end to the other, so that in effect it represents a large screw. There are forty of these grooves in the entire length of the cylinder. The cylinder turns steadily while the instrument is in operation, upon a vertical axis, its face being presented to the steel point of the receiving apparatus. The shaft on which it turns is provided with a screw-thread and works in a screw bearing, so that as the shaft is turned (by handle) it not only turns the cylinder but carries it upwards. The rate of this vertical motion is such that the cylinder behaves precisely as if its groove worked in a screw bearing. Thus, if the pointer be set opposite the middle of the uppermost part of the continuous groove at the beginning of this turning motion, it will traverse the groove continuously to its lowest part, which it will reach after forty turnings of the handle. More correctly, perhaps, we might say that the groove continuously traverses past the

pointer. Now suppose that a piece of some such substance as tinfoil is wrapped around the cylinder. The pointer when at rest just touches the tinfoil. But when the diaphragm is vibrating under the action of aerial waves, resulting from various sounds, the pointer vibrates in such a way as to indent the tinfoil, not only to a greater or less depth according to the play of the pointer to and fro, in a direction square to the face of the diaphragm, but also over a range all round its mean position. The groove allows the pressure of the pointer, against the tinfoil, free action. If the cylinder had no grooves, the dead resistance of the tinfoil, thus backed up by an unyielding surface, would stop the play of the pointer. Under the actual conditions, the tinfoil is only kept taut enough to receive the impressions, but yielding sufficiently to let the play of the pointer continue unrestrained.

If, now, a person speaks into the receiving tube, and the handle of the cylinder be turned, the vibrations of the pointer are impressed upon the portion of the tinfoil lying over the hollow groove, and are retained by it. They will be more or less deeply marked according to the quality of the sounds emitted, and according also, of course, to the strength with which the speaker utter the sounds, and to the nature of the modulations and inflections of his voice. The result is a message verbally imprinted upon a strip of metal. It is sound preserved in visible shape. It almost equals the story of Baron Munchausen hearing words frozen, melting into speech again. It has been spoken of as the crystallization of sound.

Having secured the record of sounds, of whatever nature, a contrivance is needed to reproduce them. This is done by the transmitter, which is a conical drum, having its larger end

open, and the smaller end, about two inches in diameter, covered with paper stretched tight like a drum-head. In front of this diaphragm is a light, flat, steel spring, held vertically, and ending in a blunt steel point projecting from it and corresponding exactly with the one on the diaphragm of the receiver. The spring is connected with the paper diaphragm of receiver by a silken thread just sufficiently in tension to cause the outer face of the diaphragm to be slightly convex. Removing the receiving apparatus from the cylinder and setting the cylinder back to its original position, the transmitting apparatus is brought up to the cylinder till the steel point just rests, without pressure, in the first indentation made in the tinfoil by the pointer of the receiver. If, now, the handle is turned at the same speed as when recording the steel point will follow the line of impressions, and vibrate in periods corresponding to impressions produced by the point of the receiving apparatus. The paper diaphragm being thus set into vibrations of requisite kind in number, depth, and side range, there are produced precisely the same sounds that set the diaphragm into vibration originally. Thus the words of the speaker are heard issuing from the conical drum in his own voice, tinged with a slightly metallic or mechanical tone. If the cylinder is turned more slowly when transmitting than in receiving the voice assumes a bass tone; if turned more quickly it is given in a treble voice.

An infinite number of copies can be made of tinfoil impressions by making plaster-of-Paris casts of the original and rubbing off impressions from it on a clean sheet of foil.

In the last machines the screw-feed thread has been increased from forty to one hundred. The recording stylus is now a cup-shaped affair, and gouges out rather than cuts in

its motion. Both the recording and the reproducing styles are now made of sapphire, as the recording surface now employed will turn the edge of the sharpest steel tool. They are both firmly attached to the face of the one glass disc, or diaphragm, thus rendering an extra reproducing disc unnecessary. The recording stylus is free in its action and has an oscillating motion, so that it can inscribe any form of sound on the cylinder.

A hinged weight, having a compound motion, is fixed to the face of the glass disc to regulate the movements of the reproducing stylus and to adjust it in case of any inequalities in the surface of the cylinder. This automatic reproducer will follow the track of the recorder faithfully, no matter how irregular the surface may be.

The recording cylinders now in use are a hard wax composition of a dark brown color. They are very fragile, and have to be handled with the greatest care. In sending them from place to place it is necessary to pack them most carefully and send by express, as transportation by mail is very risky. These cylinders are about a quarter of an inch in thickness and are sloped toward one end. This is done that they may conform to the metal cylinder on which they are slipped to be used. This sloping is to prevent their reversal when they are to be used in reproduction. It is now impossible to make a mistake in putting them on to the cylinder.

At the back of the machine is a turning-rest holding a sapphire knife used in cleaning or shaving off the surface of the cylinder after its contents have been transcribed or it is of no further service. Thus a fresh surface is presented for the recording stylus to indent. This shaving may be done from thirty to a hundred times, according to the thickness of the shaving taken off.

The receiver is a glass disc of about eight thousandths of an inch in thickness. It is set into a metal cup and thus held in position. These receivers are manufactured abroad.

Despite the number of improvements and patents, the machine of to-day is practically the same as first issued. It has not been found necessary to make any fundamental change. Those required have been of practice rather than of principle.

By abandoning the metallic transmitter it was found that the unpleasant metallic sound heard in transmitting or reproducing was entirely done away with, and that all sounds could be enunciated by the machine as accurately as received by it. The hearing tubes of to-day are small rubber tubes, two or three feet in length, branching below the chin, when held in position, into a smaller tube for each ear, which is fitted with a hard rubber bell. These are held against the ear, not thrust into it. Phonographs are now arranged so that several sets of these tubes can be adjusted for hearing simultaneously. By this means an entire class is able to listen to a lecture at once.

It is thought by many that Edison should have a place beside Columbus, for while the greatest of discoverers succeeded in locating the New World, this new discoverer, this savant of our day, has greatly increased its usefulness and conferred upon it a new claim to universal consideration.

The inventor considers the main utility of the phonograph to be for purposes of letter-writing and other forms of dictation. The advantages in this direction are numerous. The time of the stenographer is entirely saved, as the "dictation" can be given when the typewriter is at work at something

else. Dictation is not necessarily confined to business hours as the pronograph is always ready for use. It never tires nor grumbles at long hours or overwork. There is no question regarding inaccuracies, for the machine cannot speak a single word that has not been spoken into it, nor make a questionable sign which may mean several things, as is so often the case with stenographic outlines. Neither dictator nor transcriber is limited in speed. It will record as fast as any one can speak, and reproduce as rapidly as an expert can follow it. It will repeat for the transcriber an indefinite number of times without losing its temper, and it never asks the dictator to repeat a word or sentence which he thought he had left behind some time ago. The method is so simple that there need be no loss of time by any one in learning the entire business. By the previous preparation of a number of cylinders, several typewriters can be kept busy as well as one by the ordinary means, and thus time and labor both saved.

It is adapted to all occupations in which writing plays a prominent part. Authors, lecturers, clergymen, and others will find its assistance invaluable. One minister makes use of it in this wise: He has a speaking tube running from his pulpit to the basement room of the church, where is stationed the phonograph, in charge of his son, who receives the sermon as it is delivered and repeats it to the instrument. This method has been successful from the first trial of it.

The story is told of a celebrated campaign orator, who upon being invited to deliver about two hundred lectures, at widely-separated points, procured the use of several phonographs to record his oration, which was then sent rapidly by express to the various appointments, thereby rendering him-

self, as it were ubiquitous. This way is much more satisfactory than reading a printed report, because not only the words spoken but the very tones and inflections of the voice are faithfully rendered.

One publishing house in Chicago finds that by the use of these machines there is a wonderful increase in its productive capacity. This is estimated as high as seventy-five per cent., to say nothing of the improvement in quality and the saving in expense. The members of this firm say they would as soon think of going back to tallow dips as a means of illumination as to abandon the phonograph for the stenographer with his uncertain note-book.

Mr. A. W. Clancy, President of the National Phonographic Association, says of the phonograph: "It is a faithful servant and will conduct business like a setting hen, and never strike for higher wages."

Unlike the telephone, it loses nothing said to it, but leaves a record which may be as enduring as time. It is said, however, that a machine is to be attached to the telephone, or a combination of the two instruments effected in such a manner that a record of telephone conversations may be secured. Also, that there is a machine to be attached to pianos and other keyed musical instruments to record the music played by them.

The Anthropological Society is using the phonograph for the purpose of recording and preserving the songs, folk lore, and language of the various Indian tribes which are soon likely to become extinct. The Indians call it "The Sound Writer that Talks." It is equally valuable in the class-room as a means of imparting oral information. For studies in which it is necessary to reproduce exact sounds and tones, as

in the study of foreign languages, elocution, and the like, it is inestimable.

As a practical, disinterested critic is has no equal, and by its use you may hear yourself as others hear you.

Although the phonograph is commonly spoken of as an electrical invention it is not in the least dependent upon electricity for its operation in any way. Electricity has been applied as a motive power because it is considered as the most practical, not that it is necessary. Hand power was first used, then a foot-power treadle, then a clock work motor, and finally the electric motor.

There is no doubt that as the phonograph becomes more widely known its merits will secure for it almost universal adoption in those professions and callings for which it is especially adapted.

## LIGHTING BY GAS.

THERE is perhaps no more wonderful invention than that which enables the modern man, by the mere turning of a screw to flood his house with a light second in brilliancy and usefulness only to the great solar light. It is a striking illustration of the acuteness of the scientific mind that it should have dreamed of utilizing in this way so elusive a thing as a colorless, formless fluid, whose very presence could not be detected by the eye, but required the revealing touch of a match to make it visible.

The ancients possessed slight knowledge of any aeriform bodies, except the atmosphere. Some of the early writers indeed made mention of artificial gases under the designation of *spiritus* or *flatus*, but they seem to have had an impression that these were but impurities of the atmosphere. Paracelsus, a Swiss alchemist of much renown, made the observation that gas was evolved by the action of the oil of vitriol on iron, but this discovery he appeared to regard as of no especial consequence. The early alchemists by their experiments and their ofttime fruitless searchings for the unattainable, learned, nevertheless, much of natural objects and natural science. And it is to them that the world owes many of the discoveries which have been utilized for the benefit of mankind. It is to an alchemist, Van Helmont, that the dis-

covery, in 1624, of the gaseous composition of atmospheric air is due. Observing carbonic acid gas in the Spa waters of Germany, he regarded it as an aeriform, elastic substance, which could be obtained only by the act of chemical decomposition. As it seemed more of an essence than common air, he denominated it *Gheist*, the German name for ghost or spirit, and from this is derived our English word gas. It was many years before this discovery of Van Helmont's was made the basis of any practical use.

The manufacture of gas was without doubt suggested by experimenting with the natural gas which issues from the earth in various parts of the world. Strabo, Plutarch, and other ancient authors speak of perpetual fires which burned upon the altars of some of their deities, and in the works of Herodotus and Vitruvius we find mention of the bituminous wells of the island of Zante, which cast forth streams of inflammable vapor. To the simple-minded and superstitious people these phenomena were regarded as miraculous manifestations, and the priests availed themselves of these fires to inspire their credulous devotees with greater reverence for priestly supernatural power. Such wells were found in remote times in India and China, and the inhabitants are said to have conveyed the gas through bamboo pipes, and to have used it for boiling salt.

Natural gas wells are found also in England and in the United States. In Bloomfield, Ontario County, New York, one of these wells is said to yield daily about four hundred thousand cubic feet of gas. Other remarkable gas wells exist in Ohio, one of especial interest being situated near Gambier. The gas from this well has continued to issue without cessation since 1866, with no diminution of volume.

When a lighted match is applied to the stream, as it flows from a two-inch pipe, a flame twenty feet or more in length is produced.

It is not surprising that the ancients, in whose theology fire has always figured more or less conspicuously, should have regarded such phenomena as natural fire issuing from the ground with reverential awe and fear. It remained for later and less superstitious generations to not only examine critically, but to seek to artificially imitate these burning fountains. In the Wigan coal district of Lancashire, England, was a well on the surface of whose waters a perpetual fire was burning. When a light was touched to this water, it was found to burn like oil. Mr. Shirley, a gentleman residing near this spring, soon saw that it was not the water which burned, but that something emanating from the earth was the burning substance. He proved this by draining the well of its water, and then setting fire to the dry earth remaining, which immediately burned with a flame a foot or more in height. By a series of experiments he discovered that the waters of the spring were impregnated with carburetted hydrogen gas, proceeding from the seam of coal underlying the earth about the spring. Mr. Shirley wrote to the Royal Society of London, describing his experiments with this spring, and these observations of his were, nearly a century later, duplicated by a clergyman, Rev. John Clayton, who published a book containing an account of his investigations. In 1726, a number of interesting experiments were conducted by Dr. Stephen Hales, between whom and Mr. Clayton rests the credit of having been the first to produce gas by the distillation of coal. In 1733, Sir James Lowther addressed a paper to the Royal Society on the subject of the "inflammable air"

which issued from a coal pit near Whitehaven, Cumberland. This air, he explained, was easily lighted, and was with difficulty extinguished. He collected some of the air in bladders and burned it before the Society, and so great was the impression created by his experiments that, some years later, the idea was broached of carrying this gas in tubes to the town for purposes of lighting. But this scheme was looked upon by the conservative community as wholly impracticable and chimerical, and was shortly abandoned.

In 1767, the important discovery was made by Dr. Watson, afterward Bishop of Llandoff, that coal gas does not lose its inflammability or elasticity by being passed through tubes immersed in water, which is equivalent to saying that its illuminating properties are unchanged by the condensation of some of its constituents.

The idea of utilizing the gas obtained by these various experiments for illuminating purposes seems first to have occurred to a Scotch engineer, William Murdoch, living at Redruth, in Cornwall. He discovered that, by means of carefully regulating the processes of carbonization and condensation, he could obtain a uniform product of high illuminating power. He conceived the notion of confining the gas in receptacles, and conveying it through pipes for lighting houses. In this manner he lighted his own house, carrying the gas from his gas-works, about seventy feet distant. He invented, also, a portable gas lantern, which he used to light his steps on his night excursions about the country. This latter achievement was regarded with much disfavor and not a little apprehension by the superstitious country folk thereabouts, and the clever engineer suffered the penalty of other minds in advance of their time in being seriously suspected of practicing witchcraft.

In 1798, Murdoch erected works for the manufacture of gas at the Soho Foundry of Messrs. Boulton & Watt, near Birmingham, and became himself the personal superintendent of the works. On the occasion of the peace of Amiens, in 1802, Mr. Murdoch brilliantly illuminated the foundry with unique devices, and the superiority of this new mode of illuminating was thus vividly impressed upon the admiring and astonished spectators. The use of gas for lighting purposes began, after that time, to be adopted by cotton mills and other establishments, although people were strangely slow in availing themselves of so obvious an improvement on former methods. The Lyceum Theatre, of London, was the first place of amusement lighted by gas.

Gas had, like other innovations, to encounter much opposition and scornful incredulity. The great Napoleon, who had the misfortune to be a man of occasional grave mistakes, is said to have remarked, when informed of the project of lighting a city by gas: "*C'est une grande folie.*" Even Sir Humphrey Davy inclined to consider the whole matter as the impractical dream of a visionary enthusiast.

In 1801, a Frenchman named Le Bon had discovered the secret of producing gas by the distillation of wood, and had used this gas for lighting his own house. Before Le Bon had carried out his plan of illuminating the city of Paris with this gas, another man had arisen who proclaimed himself the inventor of gas-lighting. This aspirant for the inventor's honors was a Mr. Winsor, a German, who was suspected of having been an assistant of Le Bon's, and of having gained the knowledge that he possessed from his master. His claims were widely disputed, but he persisted in his attempts to establish a gas manufactory so untiringly that his efforts were at length crowned with a measure of success.

The first American city to be lighted by gas was Baltimore, and the first charter to an American gas-light company was granted in 1816. Boston adopted the new mode of lighting in 1822 and New York in 1823, and the superiority of gas lighting over methods previously in vogue being now fully demonstrated it was rapidly introduced into all the considerable cities of the country. The Baltimore gas company originally undertook the manufacture of gas from coal-tar, but this proving a complete failure, the works were remodeled, and the gas then made from bituminous coal.

Many raw materials may be employed in the production of illuminating gas. Almost any combustible body when distilled yields gaseous products available for generating light. Among materials which have been used for this purpose are coal, wood, resin, peat, oil, fats, bones, and other substances. Bituminous coal is, however, most largely used, being for many reasons the most successful material. When this coal is burned in air it is mostly converted into gases which combine with oxygen, but when the air is excluded, as is the case when coal is burned in retorts, these gases, not being able to unite with oxygen, may be collected into receptacles, thence conducted into tubes and burned. A great number of gases, liquids and solids, are produced by the distillation of coal, the principal of these being coke, tar, olefiant gas, and sulphuretted hydrogen. The products of distillation are dependent upon the degree of heat to which the coal is subjected. At a low temperature the weight of coke in the retort will be less, and the amount of carbon remaining in combination with hydrogen greater, but these hydrocarbons will be mainly liquid and solid, not gaseous. At a high temperature, on the contrary, the greater will be the weight of coke or carbonaceous

residue, and the proportion of permanent gases and their lightness also will increase in proportion to the heat. They may be composed almost wholly of hydrogen and carbonic oxide. A moderate temperature is preferable in the manufacture of gas, and the quality of coal or other substance used will also condition this.

In the production of gas from coal, as also from wood, resin, or petroleum, the material is subjected to three different processes. These are: First, distillation of the crude gas; second, the separation of the gas from condensable matter, as tar, etc.; third, the purification of the gas from all injurious and undesirable gases. For the purpose of distillation the coal or other material is put in fire-clay retorts placed in furnaces, one furnace being arranged to hold from five to ten retorts.

A large gas establishment may contain as many as a hundred furnaces. Iron was formerly used for making these retorts, but fire-clay has been proved to be more durable and fully as impervious. The coal is placed in the retort, which has been raised to a red heat, and a heat of about twenty-two hundred degrees applied to it for five hours. By this means the solid and gaseous products of distillation are obtained, and the volatile gases, being all except the coke, are passed into a tube inserted in a hydraulic main. A portion of the gases are here condensed, and those still uncondensed pass into another large pipe to be carried to the cooler and condenser, where they are conveyed through a series of peculiarly-shaped pipes surrounded with water. From the condenser the gas passes to another apparatus designed for still further purification.

In some gas works what is called a washer is employed for this latter service, consisting of a vertical chamber through

which the gas is passed, and at the same time subjected to repeated spraying from jets of water. The impurities which still remain, being chiefly sulphuretted hydrogen and carbonic acid, are then removed by still another process. The gas is for this purpose sometimes passed through milk of lime, which is called the wet lime process, or through layers of protochloride of iron mixed with quick-lime, or sulphate of iron and slaked lime. Much care is required in the management of these slaked-lime purifiers, as the gas is apt to escape and combining with the air to form a dangerous explosive, from which grave accidents have resulted.

The illuminating power of the gas depends chiefly upon the amount of olefiant gas, heavy carburetted hydrogen, which it contains, the majority of the other gases being carriers rather than producers of light. The luminosity is also affected by other things, depending much upon the form of the burner. If burned in a very tall chimney, so that a rapid current is produced, it has been observed that the illuminating power of gas may be greatly lessened. Small or thin flames are also undesirable, since the thinner the flame the greater is the exposure to the oxygen in the air, and the swifter consumption of the solid portions of carbon. By the careful distillation of two thousand pounds of good bituminous coal, eight thousand cubic feet of purified illuminating gas may be produced.

Connected with the gas works are meters, by which the volume of gas is registered before it passes to the reservoirs. From the reservoirs it is conveyed through cast-iron main pipes through the streets, and from these in small wrought-iron pipes into buildings.

Other materials, besides coal, have been employed with

varying degrees of success in the production of illuminating gas. Le Bon's experiment with wood, in the eighteenth century, was not found practicable, as the gas produced was inferior in illuminating power to that manufactured from coal in England. The reason assigned for this was that the heat used was not sufficient to produce the heavier hydrocarbons. Professor Pettenkofer, of Munich, showed, by experiments, that the gases evolved by the carbonization of wood consist almost wholly of carbonic acid, carbonic oxide, and marsh gas. Olefiant gas, on which the illuminating power largely depends, was nearly wanting. But he proved that the tarry substances and vapors produced would, when subjected to a much greater heat, produce a large quantity of heavy hydrocarbon gas. It is necessary, therefore, in the manufacture of wood gas, that there should be retorts for changing the wood into tarry vapors, and others, where, by the application of a higher heat, these may be converted into permanent gases. The hydrocarbons in wood gas have been found to have an illuminating power one-half greater than that of an equal volume of olefiant gas. It has a specific gravity somewhat greater than that of average coal gas, which necessitates the use of burners with larger orifices. The production of gas from wood has been for some time successfully accomplished in Germany.

Gas has been made from resin, and a product of high illuminating power has resulted. It was some years ago employed in Philadelphia to add to the richness of coal gas, and several towns in the southern part of the United States still manufacture it, but the limited quantities of the raw material render it unavailable for extensive use. Petroleum has been much used in Germany, Austria, and Russia, and also to some

extent in the United States for the making of gas. The raw oil is conveyed from a reservoir into cast-iron retorts, heated red hot, and from these it passes into an apparatus for purifying it, in which hydrochloric acid is one of the agents employed. It is estimated that one hundred weight of Pennsylvania oil will produce about sixteen hundred feet of gas. This gas is the richest made, two hundred cubic feet of this being considered as nearly equal in illuminating power to one thousand feet of coal gas.

The last material which an unscientific mind would pronounce available for the production of gas would doubtless be water, and yet many inventors have received patents for making gas from water. It was discovered that when steam was forced through retorts in which were red-hot coke, charcoal, or anthracite, there were generated hydrogen, carbonic oxide, carbonic acid, and a small amount of light carburetted and of sulphuretted hydrogen gases. Purification by means of lime, or lime and oxide of iron, removed the carbonic acid and the sulphuretted hydrogen, and the gases remaining might then be used for purposes of heating, or, by one of two processes, might be available for illuminating. These processes are, by heating coils of platinum wire in the flame, or by impregnating it with hydrocarbon vapors, or by uniting it with permanent hydrocarbon gases, the latter being found the most satisfactory means.

Selligue, a French gas engineer, invented a process for manufacturing water gas, having received the suggestion which led to his invention from Jobard, of Brussels. This appliance consisted of a furnace provided with three vertical cylindrical retorts, two of which were filled with charcoal or coke. Steam was passed into the first retort, where the

various gases were evolved. They were then conveyed into the second retort, where the carbonic acid was changed by the red-hot coke or other burning material into carbonic oxide. From this they were carried to a third retort, in which a stream of oil from bituminous shale flowed over red-hot iron chains. A Mr. White, of Manchester, patented later a process designated as the English hydrocarbon process, in which the retorts were quite similar to those used in making ordinary coal gas. Anthracite is said to be used more satisfactorily in the production of water gas than either coke or coal.

The employment of electricity in late years as an illuminating agent has given rise to the belief in many minds that it may in turn supersede gas altogether, but there seems as yet little ground for such apprehension. Both gas and electricity as a means of lighting appear to possess superiority, in the application to different purposes, and so long as that is the case there would be found no reason for the sole employment of the one to the exclusion of the other, unless, indeed, electric lighting should prove a far cheaper mode of illuminating, and that seems yet a thing to be demonstrated.

## SUBTERRANEAN EXPLORATIONS.

VISIONARY and extravagant accounts of the wonders and wealth concealed in the depths of the sea have always obtained ready credence. Alluring stories of the sunken Spanish galleons laden with gold, silver, and precious stones have tempted many a bold diver to his destruction. The sunken treasures of Captain Kidd, Black Beard, and other daring, if less known pirates have been responsible for many attempts to solve the mysteries of the deep. In narratives of ancient date we are told that the pearl and sponge divers of the East were able to remain under water two hours without the aid of air-giving apparatus. It is needless to say that no such endurance is possible. The depth to which they could descend and the time of their immersion have been much exaggerated. A skilled diver—without extraneous aid—can remain under water but two or possibly three minutes. In a diving and swimming contest between some North American Indians and Englishmen in a London swimming bath, one of the Indians, a noted swimmer and diver, remained under water just one minute and a half, but a London artisan beat him by a few seconds. A few rapid respirations before the diver makes the final plunge will enable him to remain longer under water. It can be readily understood that if the blood be forced to take an

excess of oxygen a longer time should elapse before a fresh supply would become necessary. Many divers without apparatus suffer severely from the continual efforts to hold the breath. Spitting of blood and inflamed eyes are common among them. At the close of the pearl and sponge diving seasons the divers emerge from their labors with golden locks that would be the envy of a belle of civilization. This is a sufficiently curious phenomenon when seen in connection with the black and shining epidermis of the Malay pearl diver. This curious change is brought about by the chemical action of the water. There is little doubt that the efforts of the primitive diver were directed to the acquisition of some of the vast wealth supposed to lie at the bottom of the sea, and only incidentally to the gathering of sponges and pearls.

As civilization advanced and the need arose for the building of the foundations of piers and bridges and the exploration and raising of sunken vessels, the attention of engineers and philosophers was turned to the discovery of a contrivance for aiding the diver in prosecuting his dangerous but important calling. The aquatic kettle, described by Taisnier as having been used by two Greeks in Spain, at Toledo, in 1538, in the presence of the Emperor Charles V and a vast multitude of spectators is one of the earliest reliable accounts of a diving bell. It was similar in construction and principle to the modern diving-bell, but clumsy and cumbersome and wanting in efficient means of renewing the supply of air. Dr. Halley, the noted English astronomer, made some valuable experiments with the diving-bell in 1720, but it was not until 1788 that Smeaton's—the one now in use—was made and found to fit the requirements of submarine explorations. The Greeks, by far the most richly endowed in constructive

imagination of any of the ancient people, gave little thought to the regions beneath the sea. The true love of the deep and interests in its hidden regions has been confined to the people of modern days, and especially to the people of Northern regions.

The principle of the construction of the modern diving-bell may be readily understood by placing an insect or two upon a cork in a pail of water, invert a tumbler over the cork, then push the apparatus to the bottom of the vessel; on raising the glass to the surface the little voyagers will come up perfectly safe and unsoaked. The diving-bell as now used consists of a cast-iron chest, weighing about five tons and suspended by blocks and tackle.

On the top of the bell there are eight apertures fitted with very thick glass for admitting light, and in the centre is the passage into which the hose is screwed for admitting the air supply. The interior is fitted with two seats which can be removed to make room when the men are at work, and in the centre is a lifting chain to which stones are attached to facilitate their being lifted and properly adjusted to the beds on which they are to be laid. The bell is used according to two different systems, depending on the nature of the work to be performed. In building masonry under water it is suspended from a staging of timber, but in excavating rock or removing boulders scattered over a considerable area where a staging would be impracticable, it is suspended from a barge or lighter. The invention of the diving dress, like that of most useful appliances, was graduate and the work of many minds. The diving dress, known as the open dress, first invented in 1829, although excellent in many of its features, precluded the possibility of the wearer being in any other than an up-

right or slightly sloping position; if he fell on his face or side there was great danger of drowning. The need of a dress that would meet the requirements of any position the diver might be placed in led to the invention of what is known as the close dress, which is now in universal use. The long-continued work of divers in connection with the removal of the wreck of the "Royal George" suggested many improvements in dress and equipments, which have stood the tests imposed upon them. The diving dress envelopes the whole body of the diver—the upper portion being the helmet, the intermediate portion being the breast-plate, and the lower portion the dress. The water-proof material, of which the dress is made, is generally of sheet India rubber, covered on both sides with tanned twill to protect the India rubber from injury.

The sponge, coral, and pearl fisheries, originally carried on only by naked divers, are now conducted to a great extent by artificial aids. At moderate depths, not exceeding thirty to forty feet and in clear water, sufficient light is transmitted to enable the diver to perform any ordinary work, but in working in turbid water candles are employed. An electric and an oil lamp have been constructed which can be employed by divers requiring the use of a light at great depths.

The depth at which diving can be safely conducted is a question of importance. The ordinary depth at which diving has been employed in harbor work is from thirty to thirty-five feet, and it has been used sixty feet at Dover. With the diving dress much greater depths have been attained. In removing the cargo of a sunken ship off South America, a diver named Hooper made seven descents to a depth of two hundred and one feet, and remained below forty-two consecutive minutes. This feat is said to be unparalleled.

It is difficult for a diver to walk against even a moderate tide, and men who, by accident, get on the tide side of their work generally have to be hauled up to their boat and lowered down again in order to get on the windward side of it. There is less difficulty in making bell divers than hemlet divers, probably on account of their working in company—there being always two men in a bell, and the same amount of self-reliance is not needed. The sensations experienced in a diving-bell are common in greater or less degree to all divers; when the bell first touches the water pain in the ears and above the eyes is felt, which continue while the bell is in motion. When the bottom is reached, there is a cessation of these symptoms, which are replaced by a feeling of depression, the acuteness of which depends on the depth of submersion. The motion of the bell, up or down, is very gradual—not exceeding three feet per minute, but even at that slow rate the pains in the head are considerable

The workmen accustomed to subaqueous existence do not feel these inconveniences, but the novice suffers greatly. The work is unsuitable for any but the most robust—those of a full habit of body being in as great danger as the weak and bloodless. A melancholy interest attaches to all subaqueous explorations. In imagination we see the whitening bones of the pirate beside the ghastly skeleton of his hapless prey—the bolting, beams, and planks of the merchantman—freighted at its setting out with high hopes of the fortune to be won; its harbor, alas! the twilight-calm and awful hush of the abysmal depths of ocean.

The ancients used to say that the ocean was the son of the sky and the land, and father of the rivers and fountains. Had it occurred to them, they might have carried the simile still

further, and said that the earth was the child of the deep, for everywhere upon its surface the ocean's bed is only covered by a few inches of alluvial soil.

Until recently the physical and biological conditions of the deep sea were entirely unknown, and likely to so remain. The idea of a lifeless waste at the bottom of the sea was so generally prevalent that any evidence to the contrary would scarcely secure the least attention. It was thought that organisms, brought up by the sounding line, were met and captured in transit. The difficulties in the way of early investigators were very great. The diver was restricted in his work to about twenty fathoms, or one hundred and twenty feet. At this depth there was a pressure upon him of five atmospheres, or seventy-five pounds a square inch, which was equal to about one hundred and fifty thousand pounds on the entire body.

It is said of this time: "The restless intellect of man, which, ages before, had sought to solve the riddle of the Universe, to penetrate the mysteries of the stars, to make tributary to itself all time and all space, scarcely cast a glance of interest toward the great world of life under the waters." Soundings had, indeed, been made. They had even been dignified with the name of "deep-sea soundings," but those descending to the greatest depths possible only touched the peaks of some submerged mountain range, or brought to view some specimens of the life on some lofty plateau, or table land, of the great volcanic chains. But modern science and ingenuity have set before us the bounds and measurements of this submarine realm, and it has become geographically known to us. The contour of the bottom of the ocean has been found to be not unlike that of the land above

it. Mountain systems, deep gorges, valleys and plains abound. Between the types of life in sea and land there is a sort of inverted analogy. They become fewer as they recede from the sea level, and the conditions are more severe.

The first exploration of these submarine areas was effected by means of the sounding lead and line. By them the depth was ascertained, and fragments of earth brought to the surface for examination. The primitive instrument used was a single prismatic block of lead, weighing from eighty to one hundred and twenty pounds. On the upper end is fixed a ring, to which the line is attached. When a sounding is to be made, the lower end, or base upon which it rests, is coated with tallow, and the lead plunged rapidly into the water. In moderate depths the slackening of the line indicates that the lead has encountered an obstacle and will go no further, but in great depths this method cannot be relied upon to give correct information or accurate results. Should the line be strong enough to sustain the weight of any considerable part of its own length besides the weight of the attached lead, it will be too stiff and heavy to be carried plumb to the bottom by the lead; should it be any lighter, it breaks under the strain required of it. An improvement on this device was introduced into the United States Navy some years ago. A fine line, the length of which has been measured, has a heavy weight attached to it. It is quickly lowered into the water. When the pull upon the line ceases it is at once cut, and the length of the missing line represents the depth. But this would only record measurements. The soil and sand secured by the other method gave important information as to the nature and composition of the ocean's bed. But these specimens were so small that it was soon found necessary to adopt

some more satisfactory means for the pursuit of scientific investigations. For this reason dredging was resorted to, and has proved eminently successful.

The idea of deep-sea dredging had been entertained by the scientific world for a long time before actual experiments in that line were made. It was thought to be a possibility, but neither a motive for its undertaking, nor the means of its accomplishment were at hand. Later the commercial world required a more direct and speedy means of commercial intercourse across the ocean, so the first proof of the feasibility of deep-sea exploration was in response to a practical, not scientific demand. The necessity for laying the various telegraphic cables supplied the wanting incentive, as well as the perfection of the appliances requisite to carry out the work. It had been demonstrated that dredging at depths could be done, and that, too, in the face of numerous difficulties, but as it was a process so laborious and requiring so many favoring conditions for its successful performance, it became necessary to secure some more effective and simple machinery for gaining the required information of the physical peculiarities of the ocean's bed. This resulted in a combination of the sounding line and the dredge.

There are several forms of these instruments in use amongst naturalists. One is described as a huge pair of forceps which form a chamber when closed. The arms are held asunder by a bolt, and it is heavily weighted. Upon striking the bottom the bolt is displaced, the forceps close upon the mud of the sea bed, and the instrument is ready for the upward pull with its inclosed freight. Another and more popular form consists of a tube of metal, whose lower extremities are provided with valves that open upward. The

tube passes through a perforation in the cannon ball, used as a weight to the instrument. When the end of the tube strikes the earth, the mud, sand, or whatever there is there for it to encounter, fills the tube through the opening valve. The weight is disengaged and the valve closes as the instrument is drawn up through the water. The tube may be unscrewed and the contents examined at leisure.

The principle of the detaching weight, which was invented by pass-midshipman Brookes, of the United States Navy, is of incalculable value, as it enables the deep-sea explorer to accomplish his purpose with less labor and less machinery and secures the great advantage to be acquired in the use of a fine line. Frequent and carefully repeated soundings by this method show the error of the earlier investigators. The old method reports various lengths of thirty-four, thirty-nine, forty-six, and even fifty thousand feet of line as having been paid out, at different points, without finding bottom. By the new method, working in exactly the same localities, there has been found no greater depth than twenty-four thousand feet.

When it became necessary to lay the cable there could be no guess work about its bed. The consequences were far too momentous to admit of mistakes, or even the question of a peradventure. The information must be exact.

The Mediterranean telegraphic cable was stretched in 1857. It worked satisfactorily until 1860, when it was discovered that it was severed in seventy fathoms of water and about two miles from shore. After much angling for it and strenuous effort, the sea end was secured and brought up. That portion of it which had lain in the deep sea was covered with marine life. Thus, the first news from the profound

depths may truly be said to have been a telegraphic message. A list of these organisms was made out and recorded by Dr. Allman. The depth varied from seventy fathoms to one and a half miles. All former methods could not be implicitly relied upon, because, as has been already said, the sounding line might bring up animals from any depth, and there was no known way of ascertaining whether their true *habitat* was at the bottom of the sea or not.

Dredging before the preliminary work for the laying of this cable had seldom been deeper than six hundred feet. Any device or machinery hitherto in use was greatly inadequate for the giant enterprise which at this time confronted the scientists. At this juncture Great Britain came to the front with an offer, not only of all known appliances best adapted for the work, but vessels, seamen, and a corps of naturalists, sufficient to execute the plan. They were able to dredge and sound to a depth of nearly three miles with perfect success. In earlier attempts the labor of hauling in the rope was excessive. The use of an engine for this purpose was now introduced.

It is estimated that by means of deep-sea explorations one hundred and forty million square miles have been reclaimed from scientific death. This surface, on which it was previously supposed that nothing could exist, has been proved to be teeming with rich and exquisite forms of animal life, no less varied than the fauna of the shallower waters. These organisms are celebrated for their soft and beautiful colors, their wonderful phosphorescence of rainbow tints, and their elaborate and delicate formations. There are continually being brought to light new wonders and beauties, which elicit great admiration, both for their intrinsic value and for

their aid in the solution of this weighty problem. The report of the cruises of the "Porcupine" and "Lightning" show that hauls made at depths of three thousand and more feet, as well as those of six thousand feet, proved life to be abundant at each depth. There were fifty-seven of the former hauls and sixteen of the latter.

In two casts taken off the mouth of the Bay of Biscay, at a depth of nearly three miles, characteristic specimens of all five sub-kingdoms of the invertebrates were brought to the surface, carefully examined and classified. Thus was finally settled the existence of a profusion of animal life in the profoundest depths. The specimens brought up by the broken cable, before alluded to, were not merely clinging lightly to the surface, but were firmly cemented to it, and many gave evidence of having grown there. These deep-sea organisms are adapted to the locations in which they are found. They are so constructed that the intense pressure upon them does not seriously affect them. On account of the low temperature of the water they do not reduce their own temperature by exercise. Sharks taken from these great depths are incapable of movement when brought to the surface, while those that live at the top always have to be struck and gashed to quiet them.

The geographical distribution of animal life depends upon the deep-sea temperature, which is not determined, as it is on land, by the latitude. The water is generally colder as we descend, and it is o degree at the ocean depths. In some places the water forms what is called a "cold wall," with currents flowing around it. In immediate proximity, in the North Atlantic Ocean, lie areas which show varying temperatures of several degrees. It was formerly believed that water

at the bottom of the sea was of uniform temperature, and that about thirty degrees all over the earth, but like the older determinations of depth this theory must now be discarded. The extreme cold of the deep sea does not retard abundant and vigorous animal life, but vegetable life is not found, on this account, together with the absence of light, which is essential to vegetable growth and development. Some of these latter forms drift from the spot where they grow, and sink to the bottom, but the abyssal darkness sustains no life of this kind. The animals of these great depths must live somehow, must be sustained by organic matter. How do they get it? To be sure the higher forms can prey upon the lower, but how are the lowest forms nourished? This has long been a question under discussion by scientists, and several methods have been suggested, but it all has resulted in the proof that the water holds the suitable matter in solution for their sustenance, and that they appropriate it through absorption.

The Sargossa Sea, that vast marine meadow occupying three million square miles in the middle of the Atlantic Ocean, yields an immeasurable supply of this material, the great oceanic currents transport it, every river and stream adds its quota to the ocean, every bed of seaweed contributes its share, and all these become the purveyors to the waiting life at the bottom. This life at the depths is usually of a jelly-like consistency, capable of taking nourishment only in a soluble form. The individuals possess few if any organs or special functions. They receive their nourishment through absorption through the exposed surfaces of their bodies.

Their method of breathing was another problem to be solved. The ocean water has atmospheric air diffused

through it at all depths, as is proved by analysis. Air is as necessary to the maintenance of the lives of marine animals as to those of the land, though in much smaller quantities. Carbonic acid is a product of respiration, and the layer of water immediately above this vast layer of organic life is found to be destitute of oxygen, but surcharged with carbonic acid gas. This is invariably the case. But by diffusion this gas is taken away by the water and the oxygen substituted for it. By this means the respiration of the deepest fauna is provided for through three miles of intervening water. The water is aerated by every disturbance at the surface. Every breeze or gale that skims or ploughs the top, and every paddle or other device which dips into the surface helps on the good work, and does its part toward supporting the life at the bottom.

The depths of the Mediterranean hold no life. This is owing to the absence of vertical currents in the water, as there is but little variation in the different strata of water, and the requisite commotions do not exist. As this body of water is locked within high walls never less than ten thousand feet above the profounder depths, only superficial currents through the Straits of Gibraltar can operate throughout its expanse.

Superstition played its part in hindering early investigation, as the sailors often tossed overboard the most valuable of specimens, because "it was unlucky to keep them on board the boat."

Doubts that the bottom of the sea were really a vast azoic waste were induced by the reports of Dr. Wallich, the naturalist to the "Bull-dog" sounding expedition, under Sir Leopold McClintock, that he had brought from twelve hun-

dred fathoms, starfishes with stomachs filled with the deep-sea foraminifers.

One of the later additions and improvements added to the dredging apparatus is a trawl, or net. These make the work far more effective. The trawl has an open mouth, so hung and arranged that any animals disturbed by the movements of the machine naturally swim or float into the net. They have long, frayed tassels to further entangle the passing or adjacent organisms. These tassels were added because it was found that so many specimens attached themselves to the outside of the trawl. The first ones tried were the swabs used for cleaning the decks. Captain Calver first used them. They are now large bunches of "teazed-out" hemp. The deepest successful haul of the trawl was made in the Pacific Ocean, in three thousand one hundred and twenty-five fathoms of water, that of Ball's dredge, the one now most commonly in use, was made in the Atlantic, in three thousand one hundred and fifty fathoms.

The earliest record of deep-sea dredging is that of Sir John Ross, in his Arctic Expedition, in one thousand fathoms of water. He brought up evidences of life at this depth. Sir John Franklin obtained the same results.

In 1864, G. O. Sars, a distinguished Swedish naturalist, was sent by the government of that country upon an expedition connected with the Commisson on Fisheries, and he dredged within the Arctic Circle. He brought up numerous forms of animal life. His investigations proved that there was now existent a mature form of crinoid which had before only been known as a fossil of the Oolitic period. This discovery led to the pursuit of other and further explorations under the auspices of the British Government, by the "Lightning" and "Porcupine."

The very first naturalist to use the dredge was Otto Frederick Müller, a Danish zoologist, of the last century. He operated about 1770–79 and systematically investigated the fauna of the sea. In 1779 he published his admirable *Descriptions and History of the Rare and Less Known Animals of Denmark and Norway.*

After this but little was heard about dredging until Dr. Robert Ball introduced the modern dredge named after him.

Until recent date there has not much attention been paid to dredging in the United States. In 1867, Professor Pearce, superintendent of coast survey, commissioned Count F. L. Pourtales, one of his officers, to make dredgings in connection with the laying out of a track for the cable between Key West, Florida, and Havana. These results were so satisfactory that dredgings were subsequently conducted through all the adjacent waters.

The "Challenger," a corvette of two thousand three hundred and six tons burthen, fitted out and dispatched by the British Government in the winter of 1872, on a cruise of circumnavigation for dredging purposes, did the most systematic and satisfactory work in this line that had been accomplished. It had the most liberal and complete organization for the purpose. Nothing seemed lacking. Powerful engines hauled in the dredge, libraries, laboratories, and work-rooms were provided, and a staff of the ablest naturalists were there to conduct investigations and to attend to the packing and preservation of the specimens required for future examinations.

There have been several varieties of the dredge, or dredge attachments. The Prince of Monaca used one with an electric light attached to attract the fishes. There were dredges

used by the Suez Canal Company having connected with them an apparatus, or battering ram, for breaking away the rock obstructions.

The world has been long engaged in submarine investigations. Diving for oysters was practiced in Homer's time. Roger Bacon says that Alexander was possessed of some artificial means of seeking out the secrets of the deep. Bladders over the mouth were the first contrivance for artificial assistance in diving. In the year 380 the diving cap was in use. In an expedition of the Greeks against Syracuse divers were employed who sawed the wooden stockades placed under water at the mouth of the harbor to prevent the Greek ships from entering.

The result of all this investigation is to teach us to newly comprehend the ocean. "Its bosom which so teems with animal life; its face, upon which time writes no wrinkles, are, it would seem, as obedient to the great law of change as any other department of nature."

## MINING—GOLD AND SILVER

SOME one has said that gold and silver sway the movements of human life as potently as the sun and moon sway the tides of the ocean. There have been those who worshiped fame, honor, beauty, country—but the devotees of the cold, hard, glittering silver and gold have in every land, in every clime, far outnumbered them all. For, if to worship a thing be to fix one's whole mind and heart steadfastly upon it, to desert one's home and kindred, one's friends and sacred honor for it, then more people in the civilized world to-day bow the knee to the "Almighty dollar"—be it a gold or a silver dollar—than to any other deity. And this they do because gold and silver may be transmuted into almost every other material good. We may lament the worship of the material, but we are compelled to admit while we deplore.

The fact that the oldest records of the human race make mention of gold and silver, proves that the art of mining dates from a period of remotest antiquity. The Old Testament refers frequently to these metals, disclosing that they were always accounted riches. The processes of beating gold, of making it into wires, as also of weaving it into linen for priestly garments, were known to the Jewish people. They likewise used it as a setting for precious stones, and the tem-

ple of Solomon was profusely decorated with gold. We read of the beams and pillars of ancient temples being covered with plates of silver and gold, and that the tiles upon the roof of the temple at Ecbatana were made of solid silver. Idolatrous nations have in all times been wont to fashion their idols of gold and silver, the lavishness with which the precious metals were employed for these purposes clearly demonstrating the existence of mines both marvelously rich and easily accessible.

A story which has to modern ears an Oriental largeness of ring to it, yet well illustrates the ancient abundance of the precious metals. It is of the captive Inca of Peru, who, to purchase his royal freedom, promised to collect within two months gold articles enough to fill nine feet in depth a room twenty-two feet long by seventeen wide. This gold, when placed in the crucible and melted yielded no less than one million three hundred and twenty-six thousand *pesos de oro*, a sum equal to about fifteen million dollars. Truly a costly ransom.

Concerning the mines and mining operations of antiquity, classic writers have, however, left little on record. The land of Ophir, regarding whose exact location no one can now speak authoritatively, although it is supposed to have been the East Indies, or the southeast coast of Africa, was the region from which the Phœnicians and Israelites obtained their gold. The rich gold mines of Ethiopia and Nubia are supposed to have been the sources from which the Pharaohs of Egypt derived their enormous wealth. The Phœnicians are known to have mined for gold and other metals in Sardinia, and to have worked mines in Spain, presumably for lead and silver

Prior in time to the mining of the Phœnicians was that of the Egyptians, who worked successfully rich mines of gold, silver, and copper in both Arabia and Ethiopia. Ruins of mining works in the Sinaitic desert are believed to be the remains of early Egyptian mines. The gold mines of Crœsus in Asia Minor continued to be worked down to the time of Zenophon, but later writers speak of the supply of gold from these mines having become exhausted. The Grecians mined silver from very productive mines in Attica, and rich gold mines in Thrace and Thasos, and there are evidences that mining was carried on by the inhabitants of Western Europe before the time of the Romans. The early mines of Spain were exceedingly rich, and the Spanish silver mines were among the first to be worked. Pliny makes mention of a mine in what is now the province of Seville, which afforded a daily yield of three hundred pounds of silver.

Rome, by her successive conquests, gained in time control of all the most valuable mines of that period, including those of Spain, Sicily, Asia Minor, Greece, and Egypt. Slave labor was largely employed in these mines, which were leased by the government to persons who did not scruple to plunder the republic of her mineral treasures. The output from the mines was enormous, and many of them were exhausted.

There are in the United States traces of mining in prehistoric times, but such ancient mines have been found only in the copper districts of Lake Superior, and in parts of New Mexico. The implements found in these deserted mines convey some idea of the methods employed by the primitive miners. Miners' tools of peculiar design have been discovered in many of the ancient pits. Among these are great numbers of stone hammers and copper chisels, wooden

shovels, bowls, and the like. The Portage Lake and Ontonagon district have furnished many curious and interesting relics of these ancient miners, who are believed by some to have belonged to the race of the pre-historic mound-builders.

The great demands upon the mines Kuon, during the Middle Ages had resulted in despoiling these storehouses of their hidden wealth, and in the absence of new discoveries of mines, the metallurgists made countless futile endeavors to find a means of transmuting the baser metals into gold. But, although many an alchemist staked both fame and fortune on such ventures, no success was ever known to crown their efforts. The amount of gold and silver in the Old World just previous to the discovery of America is said to have fallen to thirty-four million pounds, the diminished product from the mines being no more than sufficient to make good the loss by wear destruction of the metals in circulation.

But the newly-discovered world, by the profusion of its riches, speedily much more than made up to the Old World for the famished condition of the old mines. In consequence of the vast importations of the precious metals, compared with that of other commodities, their value rapidly declined, and mines which had heretofore been worked with a profit, now no longer paid for working. It has been estimated that there was exported from the mines of America into Europe, during the eight years following the discovery of the New World, gold to the value of fifty-two thousand pounds, and the annual yield scarcely diminished up to 1521. Until 1819, gold alone was imported from America. The conquest of Mexico caused large quantities of both gold and silver, es-

pecially the latter, to flow into European countries. In 1545, the discovery of the mines of Potosi augumented still further the production of silver. After that time no accurate data are furnished for determining the relative proportion of the two precious metals. Some one has, however, roughly estimated that the amount of gold exported to the Old World by the New during the first three hundred years after its discovery was equal to three and a half times the entire yield of the old mines, while the quantity of silver exported was twelve times the Old World product.

Russia was, previous to the discovery of gold in California, the greatest gold-producing country in the world. The Russian gold region was formerly in the Ural district, but in the time of Nicholas, an exceedingly rich gold country, estimated to be as large as the whole of France, was brought to the knowledge of the government in Southern and Eastern Siberia. The yield from this district alone in 1843 was about eleven million dollars. The average annual production is now about fifteen million dollars.

Gold was first discovered in Australia in 1839, by Count Strzelecki. He at once made known his discovery to the governor of the colony of New South Wales, but the latter personage, being of the opinion that the presence of a great number of convicts in the colony made it undesirable to proclaim the gold secret immediately, prevailed upon the Count to refrain from publishing it abroad. Several other persons made within a few years succeeding the discovery that Australia was rich in yellow metal, but not until 1851 occurred the "find," which resulted in placing the former convict province foremost among the gold-producing countries of the world. Once it was noised throughout the world that gold

in large quantities had been found in New South Wales, a great immigration to this region took place. Extensive mining operations soon revealed gold deposits far surpassing in richness the fondest dreams of the most imaginative prospectors. It was calculated that the amount of gold exported from Victoria and New South Wales, within a period of fifteen months, was nineteen million five hundred thousand pounds sterling, nearly four times the supposed annual production of the entire world previous to that time. The most extensive gold mines of Australia are in Victoria. The Australian gold has a higher color than the gold of California, and is of finer quality.

Gold in the United States is found mainly in two regions, the one extending along the Atlantic slope, designated as the Appalachian region, the other extending along the Pacific Coast through California and the adjoining States and Territories. The Appalachian gold region stretches down through portions of Virginia, North Carolina, South Carolina, Georgia, and sections of Alabama and Tennessee, in a belt varying greatly in width, being in some places more than seventy-five miles in lateral extent. The largest proportion of gold found in this region has been in North Carolina, in which State occur two auriferous belts extending, the one in a southwesterly the other in a northeasterly direction. Gold is said to have been found in the Southern States at an early period in the country's history, but it is only since the opening of the present century that the Southern gold region has received any special attention. North Carolina had been until 1827 the only State from which any considerable quantity of gold was obtained, but South Carolina and Virginia shortly after that date began to contribute a moderate amount of the

precious metals to the national supply. The entire amount of Southern gold presented at the mints and assay offices of the United States from the first working of the mines to the year ending in June, 1873, reached a value of something over twenty million dollars.

The gold and silver mines, upon which rests the mineral fame of the United States, are of course those of the Pacific slope region. Gold had been supposed to exist in California for several hundred years before the great discovery of 1848. A priest at the Mission of San José, had, in a book published in Spain in 1690, made mention of the finding of gold upon the placers of Upper California, and other writers at later times declared that the country possessed an abundance of gold, occurring in nuggets of from two to eight pounds. The discovery of 1848 is, however, claimed to have had an accidental origin, the abundant presence of the precious metal being revealed to a party of Americans engaged in repairing a mill-race. The news spread in time throughout the Union, and then came the celebrated gold days of 1849, a period of mining excitement unparalleled in history. A tide of emigration immediately poured into California from the Eastern States, Mexico, South America, and even from Europe and China, as soon as the fabulous stories of the hidden wealth had reached the public ear. In less than six months, four thousand men were reported at work on the new gold site, their labors resulting in a daily output of from thirty to fifty thousand dollars. Every mountain and hill that bore traces of an auriferous formation was tunneled and bored by these eager gold seekers. The sands of the rivers were washed and made to yield up their grains of wealth.

The great gold region of California is situated on the

western slope of the Sierra Nevada, and embraces a belt of country about five hundred miles in length and forty miles in width. The gold veins occur in, or in close contact with clay and sandstone formations, and likewise in granite and limestone rocks. The greatest production of California gold has been from the placers, these deposits being found in the beds of rivers, and also in what are supposed to be ancient watercourses. Gold is obtained in less abundance than in California in many other of the Western States and Territories, noticeably in Nevada—where it occurs chiefly in combination with the silver ore in the great Comstock vein—in Colorado, Montana, Washington, Idaho, and Arizona.

Silver mining in the United States dates almost wholly from the discovery of the Comstock lode in 1859, although New Mexico and Arizona had previously yielded small amounts of the white metal. The Comstock vein in richness far surpasses the famous mines of Spain and Mexico, the product for the single year of 1874 amounting to twenty-three millions of dollars. The "Big Bonanza" mine in the Comstock lode is the richest mine in the world. It was discovered in 1874. The average yield of ore from this lode is about eight hundred dollars per ton, but certain drifts have produced even two thousand dollars to the ton, and specimens have been found which contained eight thousand dollars of pure silver in a ton of quartz. The bullion from the Comstock lode yields in combination with the silver, gold, in value about one-third. Little silver is produced in the Eastern States. A small quantity is found in combination with the native copper of the Lake Superior mines, and the Silver Islet mine and other Northern Michigan mines have vielded considerable amounts of argentiferous ore.

Much of the world's gold and silver has come from Mexico, whose mineral wealth has been famous for ages. Among the treasures of Montezuma, the silver is said to have been far less in quantity than the gold, but since the opening of the silver mines in the sixteenth century, the yield of silver from Mexico has exceeded that from all other countries. From South America has been derived also large supplies of both gold and silver, the mines of Brazil, Peru, Chili, and other sections being of wondrous extent and richness. The yield from South America has much diminished of late years, but there are believed to be districts possessing gold and silver in great abundance, which, from the unheathiness of the climate, as well as from political causes, have been almost wholly unworked. Images made of gold have been discovered on the Isthmus of Panama, in the graves of aboriginal dwellers, which imply the existence of ancient mines whose locations are now unknown.

Gold is found usually in metallic form, in scales, nuggets, or grains. Native gold is found invariably in combination with from one to forty per cent. of silver. No analysis of gold has yet been made which did not give evidence of at least a small amount of silver. Gold is found often, also, in combination with various other metals, as with iron and copper. Gold ores, properly so called, are of rare occurrence. It is usually scattered in small particles through the quartz, when existing in rocks, and found in dust or nuggets, when in sand or gravel. Gold is distinguished as quartz gold, such as is found in veins or lodes, and wash gold, that obtained from placers, gravel deposits, and the like. By native gold is meant an alloy of gold and silver with some iron, copper, and

other metals. It is in this form of combination that most of the gold found in the world is obtained.

Silver is often found in the native state, although usually this metal is obtained from the sulphuret. Silver does not appear in sands or gravel, but always in rocks, and instead of being in minute particles, it is found in veins or masses of ore. A yield of forty dollars per ton of pure gold ore is a very rich product, while a yield of one hundred dollars per ton is not an unusually rich product from a silver mine. Pure silver in the mass is the whitest metal known. It is harder and stronger than gold, and in malleability and ductility is second only to the yellow metal. As a heat-conducting medium it surpasses all other metals, this among other properties rendering it best qualified to retain the heat of liquids. Silver alloys readily with most metals on melting. It occurs so invariably in alloy with gold that some one has said they may almost be said to constitute but one mineral species, which should range "from silver with a slight trace of gold to gold with a slight trace of silver."

It has been supposed by some that gold is confined to the rocks of one geological period, but this is an error. In Colorado gold is found in rocks of the eozoic age, while in the Appalachians, the gold is deposited in strata of the palæozoic age. The gold-bearing strata of Nova Scotia are slates and sandstones, which are supposed to date back to the lower Cambrian period. The strata of Wales and of Australia belong also to this period. The gold of California is said to be mainly in strata pertaining to the jurassic period, but it is believed that part of the auriferous rocks of that country are of the eozoic age.

The crumbling and falling to pieces of the gold-bearing

rocks causes the gold in grains to be swept down to lower levels, thus forming deposits of gold in river-beds. These often become covered with clay or sand to such a depth that the real nature of the auriferous formation is not suspected. Gold is sometimes found in such veins in great abundance, and by washing away the covering of clay or sand the nuggets of gold may be obtained. In such deposits have been discovered the largest nuggets of gold ever found. The largest nugget in the world is claimed to be that called the "Sarah Sands," which was found in Australia, and weighed two hundred and thirty-three pounds and four ounces troy. The purest specimen of gold known is said to be one obtained from the Ural Mountains in Yekaterinburg, in which the proportion of gold in one hundred parts of metal was ninety-eight and ninety-six hundredths. The yield of the California mines is exceedingly rich, being very near the pureness of the American and French gold coins, which is nine hundred in one thousand parts. The average proportion of gold in the product of the California mines is eight hundred and eighty thousandths; that of Australia is nine hundred and sixty-three thousandths. The richest gold mine in the world is said to be the Douglas mine, in Australia. The output from this mine is in value two hundred thousand dollars a month.

Gold mining is accomplished by a mechanical or a chemical process, or a combination of both, depending upon the nature and location of the deposit. Washing is the mechanical means most generally resorted to for separating the gold from the substances with which it is found in union. Many different ways of performing this operation have been invented, the location and circumstances determining which is

the most feasible in each instance. The method called *panning* consists in washing the earth or pulverized rock in a vessel in such a manner that the fine earth particles are swept over the edge of the vessel, leaving the gold with the larger stones behind. The stones are then removed, and the process continued until nothing but the gold mixed with black sand, usually titaniferous iron, which latter may be either blown away or expelled by a magnet. Quicksilver is sometimes used to separate the fine gold from the other materials.

The *rocker* is an invention something like a cradle, containing a sheet-iron bottom riddled with half-inch perforations. The earth containing gold is placed in the hopper, and water is then poured upon it, the rocker being at the same time kept in motion so as to let the earth with the fine particles of gold pass through the holes, which are not large enough to permit the passing of the coarser stones. The *sluice* is usually a long wooden trough, through which the gold-bearing dirt is made to pass by the agency of a constantly flowing stream of water. Various inventions are made use of to catch the gold after it is freed from the baser substances, mercury being much used to assist in this end.

The *hydraulic* process, which was invented in Placer County, Cal., in 1852, is the most celebrated gold-mining process. By this method a stream of water under enormous hydraulic pressure is hurled upon the mass of gold-bearing ore, which has been prepared by blasting for the action of the water. So great is the force of this water torrent that great fragments of rock, earth, and gravel are torn apart and swept like sand grains into the vast sluices awaiting their reception. By the employment of the hydraulic process the cost of working

many California mines has been greatly reduced. Some one has made an estimate of the average cost of handling a cubic yard of gravel by the various mechanical processes, reckoning the wages of the miners at four dollars a day. He found the cost thus calculated to be respectively: by the panning process, twenty dollars; in the rocker, five dollars; with the long tom, one dollar; by the hydraulic method and sluices, five cents. Quartz gold is obtained by pulverizing the rock containing the gold, and then separating the precious metal from the quartz by washing and amalgamating. The smelting processes are the same for the extraction of both gold and silver. For the separation of the two metals always found together, the nitric acid and sulphuric acid, or the chlorine process is generally employed.

The methods of obtaining silver from the ores may be denominated as the *smelting*, *amalgamation*, and *humid extraction* process. Silver ores, which consist mainly of native silver imbedded with other minerals in rocks, are subjected to the smelting process. Of such ores are those found in Northern Michigan. At the smelting works at Wyandotte, Michigan, iron pyrites is added to the ore, whereby a regulus consisting of sulphide of iron and sulphide of copper is first obtained. When this is in a molten condition, lead is mixed with this. After taking up the greater part of the silver, the lead separates by its own weight. The silver is then removed from this alloy formed with the lead by cupellation.

The amalgamation method invented by Bartholomé de Medina, about the middle of the sixteenth century, is the one which is practiced, with but slight changes, at the present time. The ore is first crushed, and then ground fine in circular troughs called arrastras. Mercury is then added, by

which means the silver is extracted from the other substances. The character of the ore determines in each case which process is the better adapted to the extraction of the silver.

Great obstacles stand in the way of obtaining accurate statistics as to the total production of gold and silver in the world. The statistics of the countries producing the precious metals record the amounts deposited for coinage, but these fail to give an adequate idea of the entire production. According to one estimate, the annual production of gold at the opening of the nineteenth century was about fifty-three thousand nine hundred and forty pounds troy, to which amount contributed respectively: New Granada, twenty-three per cent.; Brazil and Southern Asia, eighteen per cent. each; Chili, thirteen per cent.; Mexico, eight per cent.; Australia, six per cent.; and Peru, four per cent. An estimate made in the year 1860, shows a vast increase in the production, as well as a great change in the distribution of the product among the various countries. We find in 1860, the yield increased to five hundred and eighty-five thousand three hundred and seventy pounds troy, of which Australia yields thirty-seven per cent.; California and the adjoining States and Territories thirty-one and nine-tenths per cent.; and Russia, eleven and three-tenths per cent. In 1865, the product was five hundred and fifty-nine thousand five hundred aud eighty-seven pounds. Of this amount, California produced thirty-seven and five-tenths per cent.; Australia, twenty-seven and nine-tenths per cent.; and Russia, twelve and four-tenths per cent.

The value of the gold production of the chief gold countries in 1867, is stated as being: for the United States, fifty-

six million five hundred thousand dollars; for Australia, thirty-one million five hundred and fifty thousand dollars; for Russia, fifteen million five hundred thousand dollars. Prior to the discovery of gold in California in 1848, one-half of the entire annual supply of gold came from Eastern Russia. But since the year 1850, Australia and the Pacific coast of the United States have been the great gold producing regions. The United States raises now one-half the gold and one-half the silver of the entire world's supply. The gold yield of the United States in forty years is estimated in value as one billion nine hundred million dollars.

Tables adapted from a series of tables carefully prepared by Ivan G. Michaels, Washington, D. C., give a comprehensive idea of the increase in the world's product of gold and silver and their values, from the beginning of the Christian era to the year 1889, the latest date attainable. The figures from A. D. 1 to 1780, give the yield for centuries, after 1780, for periods of twenty years.

WORLD'S PRODUCTION OF GOLD AND SILVER FROM A. D. 1 TO A. D. 1889.

| | GOLD. | | SILVER. | |
|---|---|---|---|---|
| A. D. | LBS. AVOIR. | DOLLARS. | LBS. AVOIR. | DOLLARS. |
| 1 to 1492 | 13,472,164 | 4,445,814,120 | 30,056,635 | 616,161,017 |
| 1493 to 1600 | 1,570,200 | 518,165,600 | 51,168,800 | 1 048,960,400 |
| 1601 to 1700 | 1,985,060 | 656,069,800 | 81,814,800 | 1,677,203,400 |
| 1701 to 1780 | 3,397,460 | 1,121,161,800 | 86,796,140 | 1,779,320,870 |
| 1781 to 1800 | 782,760 | 258,310,800 | 38,678,000 | 792,899,000 |
| 1801 to 1820 | 564,542 | 186,298,860 | 22,039,260 | 451,804,830 |
| 1821 to 1840 | 759,010 | 250,473,000 | 30,291,690 | 620,979,645 |
| 1841 to 1860 | 5,633,988 | 1,859,216,040 | 36,876,870 | 755,975,835 |
| 1861 to 1880 | 7,920,264 | 2,613,687,120 | 69,012,570 | 1,414,757,767 |
| 1881 to 1888 | 2,500,639 | 825,210,445 | 47,105,840 | 965,670,098 |
| Total . . . | 38,586,087 | 12,733,400,285 | 493,840,609 | 10,123,732,862 |

The effect of the California and Australia gold discoveries is shown in the extraordinary increase for the period from 1840 to 1860, and continuing to 1880. After 1880 there is a perceptible falling off, but still an enormous production. The great output of silver from the Nevada mines, between 1860 and 1880, appears in the almost doubling of the figures for that period. When it is remembered that this increase was, with a few inconsiderable exceptions, almost wholly from one silver district, the great Comstock lode, the richness of the yield will be appreciated.

Another estimate of the total world production of the precious metals, divides it into three important periods, the first extending from the opening of the Christian era to the discovery of America, the second from 1492 to the gold discoveries of 1848, and the last from 1848 to 1889. This plan brings into prominence the addition of gold and silver to the world, by the discovered wealth of the New World, and later by the discoveries in California and Australia.

WORLD'S PRODUCTION OF GOLD AND SILVER. FIRST PERIOD—A. D. 1 TO DISCOVERY OF AMERICA IN 1492.

| GOLD. | | SILVER. | |
|---|---|---|---|
| LBS. AVOIR. | DOLLARS. | LBS. AVOIR. | DOLLARS. |
| 13,472,164 | 4,445.814,120 | 30,056,635 | 616,161,017 |

In quantity, gold to silver as 1 to 2.23. In value, gold 87.8 per cent., silver 12.2 per cent.

SECOND PERIOD—1492 TO 1848.

| GOLD. | | SILVER. | |
|---|---|---|---|
| LBS. AVOIR. | DOLLARS. | LBS. AVOIR. | DOLLARS. |
| 11,725,284 | 3,869,343,720 | 358,718,505 | 7,353,729,353 |

In quantity, gold to silver as 1 to 30.59. In value, gold 34.5 per cent., silver 65.5 per cent.

THIRD PERIOD—1848 TO 1889.

| GOLD. | | SILVER. | |
|---|---|---|---|
| LBS. AVOIR. | DOLLARS. | LBS. AVOIR. | DOLLARS. |
| 13,388,639 | 4,418,250,870 | 105,065,469 | 2,153,842,114 |

In quantity, gold to silver as 1 to 7.92. In value, gold 67.3 per cent., silver 32.7 per cent.

Probably nine-tenths of all the gold obtained is from placer deposits. Nearly three-fourths of the gold product of the United States from 1848 to 1888 was derived from the placers of California. The average yearly value of the gold product is estimated at about one hundred and fourteen million dollars. The annual production of the United States has fallen somewhat since the fifties and sixties, but still ranges at about thirty million dollars. A mining expert has been quoted as saying that there is enough gold in one little district of Colorado to pay off the entire national debt of the United States. Such statements may contain exaggeration,

but there seems no good ground for concluding that the United States resources for both gold and silver are by any means yet fully developed. An abundant domestic supply of both the precious metals would appear to be assured for many years to come.

Ancient fiscal privileges of royalty granted mines containing gold or silver to the King. In many of the grants to the colonies, one-fifth of the product of gold and silver mines was reserved as a royalty. In the gold and silver mines of Virginia, the London company reserved another fifth to itself. But it is becoming more and more the custom of civilized countries to remove all restrictions to the ownership of gold and silver mines, and to place property in them on the same legal footing as that in any other thing, with, of course, the exception, that the laws governing ownership in mining property must, from the peculiarities of such property, differ somewhat from those applicable to other forms of real estate.

It is estimated that about one-fourth of all the gold produced is used for coinage, and the remaining three-fourths is employed in the arts. The demand of gold for purposes of coining has been greatly increased of late years by the change in the monetary system of many countries from a bimetallic to a monometallic currency. This change has been made through a feeling on the part of such governments—whether well founded or not, time may demonstrate—that the shifting value of silver, and the difficulty of maintaining a constant ratio between the two metals, rendered a double monetary standard uncertain and inexpedient. Such a step as the demonetization of silver could not but result in a fall in the value of the white metal, till it reached the plane of the lessened demand.

Modern inventions in mining machinery make it possible to work at a profit now, mines which would not with former methods have repaid the expenses of working. The location of the mine, the situation of the metal-bearing vein, largely conditions of course, the expense of extracting the metal from the ore, making it difficult to calculate with accuracy what is an average expense of mining either gold or silver. The higher wages paid in the United States might at first seem to imply a greater cost of working mines in that country, than in the countries of the Old World. But in mining, as in other industries, cheap labor is found to be unprofitable labor, and the United States can to-day place her gold and silver in the markets of the world as cheaply as any country known. It is related that at the Spanish mine, Washington Township, Nevada County, Colorado, in 1887, three thousand tons of gold ore were mined at thirty-seven and a half cents per ton, and milled at twenty-three cents per ton. Thus was demonstrated a possibility of working ore worth only one dollar per ton at a profit of thirty-nine and a half cents.

The discovery of gold or silver in any country enables that country, by being in possession of cheaper coin to obtain on easier terms commodities from other nations. The gain is, in the first instance, wholly on the part of the country in which the precious metal is found. When, on the contrary, a country does not itself produce gold or silver, every increase in its circulation must be purchased with goods of real value in that country. By the rise of prices in the country in which the metal is discovered, international values are affected. Conditions of national wealth are changed. But in time the precious metal flows out into the circulation of other countries, a beneficent stream carrying widespread prosperity in

its wake, until in the process of years, by the agency of commercial operations, the nations of the world come to share in the new-found wealth of the gold-producing country. For in these latter years of international trade and intercourse, no nation's gain or loss is wholly its own. In it "all the rest have equal claim."

## THE STEAMBOAT.

THE original idea of a boat for crossing streams and other small bodies of water is directly traceable to the floating log; as the very simplest form is that log pointed at either end. Several logs were next lashed together by pliant twigs and branches, forming the raft which was propelled by long poles. The earliest Egyptian drawings show boats made from sawn planks and having numerous sails and oars.

The process of boat building has been a progress by stages; and the civilization of a tribe or nation is accurately determined by the form of boat they use. There are six clearly-defined stages of the work, and every one of these six grades still survive in some section of the world. Even the most primitive of all, the unhollowed log, is used on the northern coast of Australia. 1. Is found the floating log, rafts, or even bundles of brush-wood or reeds tied together. 2. Dugouts, or logs hollowed out, sometimes by means of fire, sometimes with the crude tools of savagery. 3. Inflated skins, or canoes of bark or skins that were stretched on a rude frame. The inflated skins were known as "balsas." 4. Canoes of bark or skins fastened together with sinews, or thongs, or fibers of vegetable growth. 5. Vessels of sawn planks or boards fastened to inserted ribs. These often hah

decks and half decks in them. 6. Vessels of which the framework is first fashioned and the covering nailed on afterward. This is the highest form yet reached.

For a long time boats were of a light draught, as they were always beached during the winter time. The Romans built their boats of light woods, as pine and cedar, but their war boats were more ponderous, being built of oak and heavily clamped together at their bows with iron or brass, that they might be used, on occasion, as battering rams. The Viking war ship was clinker built, seventy-eight feet long, seven feet amidships, five and three-fourths feet deep, and drew less than four feet of water. It had thirty-two oars and one mast, forty feet high, which probably carried a single, square sail. The galleys of Alfred, which kept these boats in check, were propelled by from forty to sixty oars, but they were only fit for shore service and could not put to sea. The ships of Canute carried only eighty men. The "large ships" of Richard Cœur de Lion, in 1190, which transported his forces to the Crusades, were only of small size and moved by sails. Henry V, during the early fifteenth century ordered the building of several large ships which were the wonder and admiration of that time. One was one hundred and fifteen feet long, one hundred and twelve feet keel, and forty-six feet beam. Both Henry VII and Henry VIII did much to encourage ship building, both for commerce and war.

In 1511, in Scotland, was built the "Great Michael," "ane varie monstrous schip." This boat was two hundred and forty feet long, which far exceeded any boat previously constructed. This, in the main, is the history of the early attempts at boat building.

For some time before 1788, paddle wheels were experi-

mented with for propelling larger boats. These were all driven by hand power.

The use of steam dates from antiquity. It is among the relics of ancient Egyptian civilization that we find the first records in the early history of the steam engine. Hero, in Alexandria, about 250 B. C., wrote his manuscript, entitled "Spectalia seu Pneumatica," in which he describes several forms of boilers used in the generation of steam which was applied to the motion of what seems to have been a variety of philosophical toys. He described the hand fire engine which is still employed in the small towns of this country.

The first steam boilers were nearly spheroidal, ellipsoidal, or cylindrical. Those of Salomon De Caus, engineer and architect to Louis XIII, in 1615, were spherical; those of Edward Somerset, the second Marquis of Worcester, in 1663, were also spherical, while those of Thomas Savery, in 1698, were ellipsoidal and cylindrical. After this steam boilers received a variety of shapes, until, upon the general adoption of high pressure, it became necessary to give them the strongest possible form. The material first used in their construction was copper, but it is now usually wrought iron or steel.

The present forms of boilers are to be classed as plain flue and tubular. The plain cylindrical boiler is the only representative of its class in common use. It is perfectly cylindrical, with heads that are either flat or hemispherical. Flue boilers are often cylindrical and contain one or more cylindrical flues, passing from one end of them to the other, under the water line, carrying the furnace gases and thus affording a much larger heating surface than could be secured without them. A cylindrical boiler having one lengthwise flue is known as the Cornish boiler, because it was first used at Cornwall,

The two-flued boilers are called the Lancashire. These flues have one-third the diameter of the boiler shell. Several tubes of less diameter are frequently used, and when the greatest amount possible of heating surface is required, tubes of from one and one-half inches to four or five inches are used. Flues are usually made by riveting the sheet-iron together, the same as for the outside shell. But sometimes these sheets are welded together. The tubes are frequently made of brass or copper, to secure the most rapid transfusion of heat through the water. Another advantage in their employment is that a much smaller boiler may thus be used, as a smaller area of heating surface will be required. A sectional boiler is one differing from the usual forms in its peculiar arrangement of water and steam spaces. In it are a large number of small, compact apartments occupying the space of its interior. It is considered that this is the safest kind of boiler, for the tubes are of material which will withstand a much greater strain than is ever required of them.

The earliest specimen of these boilers is supposed to be the one used by Col. John Stevens, in 1804, at Hoboken, N. J. He built the direct-acting, high-pressure and condensing engine, with sectional boiler, and experimented with it on the Hudson River. In the following year, 1805, his son, John Cox Stevens, patented this boiler in England. The machinery of Stevens's first boat is still to be seen, in a state of good preservation, in the Museum of the Stevens Institute of Technology, at Hoboken.

It is quite impossible to locate accurately the first use of steam as a motive power for boats. Blasco de Garay is credited by Spanish writers with applying steam to the propulsion of a boat at Barcelona in 1543. If this feat was really

accomplished, it is the first on record. Giovanni Branca, at Rome, in 1629, published an account of the mechanical application of the steam jet to the impulsion of a wheel, by forcing the steam against the vanes of the wheel, and proposed its application to many practical purposes. The Marquis of Worcester, in his *Century of Inventions*, published in 1663, tells of an appliance which consisted of steam boilers operating alternately, and of pipes conveying steam from them to a vessel in which its pressure acted in such a way as to force water upward, as had been previously suggested by De Caus. This was set up in Vauxhall, near London, and was the first instance of the practical application of steam in England. Thomas Newcomen, John Canley, and Thomas Savery patented the first steam engine which was worthy of the name; the others could only be said to be experiments. Humphrey Potter, an ingenious boy mechanic, in 1713, caused the valve gear to work automatically by means of leading cords from the beam. Henry Beighton, in 1718, substituted a plug rod, as well as the more substantial appliance still known to engineers, for the leading cords. The improved Newcomen engine came into use throughout England during the eighteenth century.

James Watt, an instrument maker at the University of Glasgow, Scotland, while repairing a model Newcomen engine in 1763, began a series of experiments, which finally made the steam engine of universal service. In 1765, he attached a separate condenser, which saved fully three-fourths each of water and heat. He also substituted oil and tallow to keep the piston from leaking, instead of flooding it from above with water, as had been the custom previously. He closed the top with a cylinder head, and protected the cylin-

der with a non-conducting covering, to prevent the loss of heat by radiation. He also applied the "steam jacket." The firm of Boulton & Watt commenced making these engines, at Soho, near Birmingham, Eng., in 1773. Watt suggested the economy of steam by its expansion, in 1769, and in 1776 a form of cut-off was adopted by him which he patented in 1782. The crank and fly-wheel were patented by Wasborough, in 1781. By these various devices it is estimated that the power of the steam engine was at least doubled.

Engines are called condensing or non-condensing, as they have, or do not have, a condenser. They are high or low pressure. High-pressure engines are those supplied with steam of fifty pounds and upwards to the square inch; low-pressure, those having forty pounds and downwards to the square inch.

Engines are classed, according to the use for which they are intended, into stationary, pumping, portable, locomotive, or marine. The simplest form is the locomotive, as in it neither the governor nor condenser is used. The oldest form of pumping engine now in use is the Cornish.

Oliver Evans, in 1779, projected the high-pressure, non-conducting steam engine. He used them to run grain and saw mills, locomotives and vessels. This is still the most common of all forms in use.

Joseph Dixon, in 1823, coupled two engines with cranks at right angles. The detachable, adjustable, or drop cut-off valve gear was patented by Frederick E. Sickles, of New York, in 1842. Zachariah Allen and George H. Corliss, of Rhode Island, first applied the governor to determine the point of cut-off. This was patented by Corliss in 1849.

The revival of the double cylinder engine with rapid motion

of piston, high pressure and considerable expansion, which have proved so economical and successful, have been the only recent features in this branch of engineering progress. The Corliss engine is the best known stationary engine. It is generally used in America and extensively copied in England.

Marine steam engines are of various forms, but a few shapes only are in general use. They almost invariably have condensers. While these were formerly run at low pressure, now sixty pounds are used.

In the early days of steam navigation, paddle wheels were exclusively used for propelling boats, but latterly the screw has almost entirely superseded them. The first use of the screw, of which there seems to be any record, was the one, by means of which the tug of Captain Ericsson, a scientific veteran, in 1837, towed the Admiralty barge from Somerset House to Blackwell and back. The paddle engines of the United States are most commonly the overhead beam engines, driven by steam of from twenty to fifty pounds pressure and fitted with jet condenser; and the high pressure, non-conducting, direct-acting engines, used mainly on our Western rivers. These are driven by steam, one hundred to one hundred and fifty pounds pressure, and they exhaust the steam into the atmosphere. This is the simplest form of direct-acting engine. The beam engine is distinctively an American type, being seldom, if ever, seen abroad. They are usually employed for vessels of great length, light draught and high speed. Screw steamers are far more efficacious than paddle-wheel steamers, not alone on account of the screw being a better instrument of propulsion, but because it allows the use of more efficient machinery and conserves a great amount of energy which is entirely wasted with the paddle wheel in putting the water in

motion, which coming in contact with the hull of the vessel is set in motion by friction and the resulting current is left behind to expend its energy by contact with the surrounding water. In the case of the screw, the currents so produced impinge upon the screw, which works at the stern of the vessel, and impart to it a part of that force which otherwise would be lost in making currents. The screws work deeply in the water and, for this reason, are not so liable to slip as are the paddle wheels. Hence, screws have become the sole instrument of propulsion where the depth of water will permit their use. The screw engines are light, compact, and speedy in their work. They use steam economically and power is applied more effectively than with the wheel. On account of their compactness, smaller size, and lightness, more paying freight can be transported, which adds greatly to the commercial value of the steam vessel.

Screw propellers are of various forms, but not many different shapes are in common use, as a few kinds are found to be most practical. The usual form has two blades of nearly equal breadth from centre to periphery, or slightly widening toward their extremities. These are more commonly used in vessels of high speed running free, as tugs. In naval vessels screws of two blades are usually employed. In the early vessels these screws were so adjusted that they could be hoisted out of the water, into a sort of "well," when the vessel was under sail, or set behind the sternpost, where their resistance to the progress of the boat was reduced to a minimum. In the largest boats the screws have three or four blades. The first use of paddle wheels to propel vessels antedates the Christian era.

To Denis Papin, the French physicist, is due the idea of the

piston. It was first employed by him in a model constructed in 1690. He is said to have experimented with his engine in a model boat, in 1707, on the Fulda, at Cassel. This ingenious man, before his invention for using steam, spent much time on a scheme for moving machinery by creating an atmospheric vacuum by the explosion of gunpowder in a cylinder. Sir Isaac Newton was at this time President of the Royal Society, before which Papin detailed his plan. The matter being left in the President's hands, he decided that while the scheme was no doubt practicable, the finances of the society were in such a crippled condition that they would not warrant a trial under its auspices, at this time.

In 1736 Jonathan Hulls secured a patent in England for moving vessels by steam power.

Numerous inventions now followed, some practical and ingenious, others only distinguished for their whimsicalities ; as one on record of a M. Genevois, a clergyman of Berne, Switzerland, in 1759, a sort of steam propeller which would expand like the foot of a duck and present a large surface to the water when pushed against it, but would fold up into quite a small compass when moved in an opposite direction. This was not found to be practical, and though several have experimented with the same idea since that time, it has never been adopted.

From 1731 to 1815, Patrick Miller, a retired Edinburgh banker, grappled with the problem of steam navigation on a small lake on his estate, in Dalswinton, Dumfreeshire, Scotland. James Taylor, the tutor of his sons, at length suggested to him that steam was probably the only agent that would successfully turn his paddle wheels. Feeling the necessity of experienced mechanical assistance, they associated with them

William Symington, a mechanic of Wanlockhead mines, who had already invented an ingenious engine for road locomotives. In 1789 another larger vessel was built and tried on the Forth and Clyde Canal, at a speed of seven miles an hour.

While the honor of practically establishing steam navigation cannot be truly claimed for any one person, it may be safely said that Patrick Miller, James Taylor, and William Symington were mainly instrumental in bringing about the great achievement. It was chiefly to the inspection and study of Symington's experiments that Fulton was indebted for his ideas on this subject. At first, Fulton's boat moved so slowly that it was pronounced a failure. But his experiments with the "Clermont," in 1807, were successful. Her passage up the Hudson is said to have struck terror to the hearts of the sailors of other crafts. "The crews shrank beneath their decks from the terrific sight, and others prostrated themselves and besought Providence to protect them from the approach of the horrible monster which was marching on the tides and lighting its path by the fires which it vomited."

The patent of Jonathan Hulls, before alluded to, by which England claims precedence to America in the matter of steam navigation, bears date of December 21st, 1736, is signed by Queen Caroline as witness, and was for a "machine for carrying ships and vessels out of or into any harbor or river against wind or tide."

William Henry, of Chester County, Pa., experimented with a model steamboat on the Conestoga in 1736. A similar attempt was made by the French nobleman, Count d'Auxirons, who was assisted by M. Perier, in 1774. M. Perier repeated the experiment in 1775. Marquis de Jouffrey was

employed in the same work from 1776 to 1783, using a larger vessel, and he found his efforts successful. James Rumsey, in the United States, in 1784–86 wrestled with the same problem. In 1786 he propelled a boat on the Potomac, near Sheppardstown, at the rate of four miles an hour, by using a jet of water forced out at the stern. John Fitch, who had an experimental boat on the Delaware, in 1786, tried the same means of propulsion. He propelled by paddles suspended by the upper ends of their shafts and moved by a series of cranks. This boat was sixty feet long. Another vessel made many trips on the Delaware, which reached an average speed of seven and one-half miles an hour. In 1796, after his return from England, where he had been experimenting on the Thames, John Fitch again resumed his experiments at New York, using a screw.

Besides these, there were several other attempts at steam navigation, more or less successful, before the advent of Robert Fulton, an American artist, and afterward civil engineer, who built a steamboat on the Seine, in 1803. He was assisted by Chancellor R. Livingstone, whom he had previously known in America. Fulton returned to the United States in 1806, and with Livingstone had a boat built in which was placed the machinery made by Boulton & Watt. This boat was named the "Clermont" and made a successful trip of five miles an hour from New York to Albany, on August 7th, 1807. The upward trip was not continuous, but the return trip occupied thirty hours. This boat, which was lengthened ten feet in 1808, and some change made in its machinery, was the first ever made commercially successful. Almost simultaneously, Stevens brought out the "Phœnix," a side-wheeler. This steamer could not ply on the Hudson, as

Fulton and Livingstone had the monopoly of navigation on that river, so it was taken by ocean around to the Delaware. This was the first ocean voyage made by steam. From this on steamers multiplied, and their power, speed, and capacity increased. Ocean navigation by steam, begun in 1808, by Stevens, became an assured success by the trip of the "Savannah" in 1819, which went from Savannah, Ga., to Russia, by way of England. In this trip both steam and sails were used. She returned direct from St. Petersburg to New York in twenty-six days. In 1825, the steamer "Enterprise" went to Calcutta from England. In 1836, there was a proposition to establish a steamer line between Liverpool and New York. The first transatlantic line to be established was the Cunard, which sent its first vessel, the "Britannica," from Liverpool July 4th, 1840.

The first naval screw boat used in the English Navy was the "Archimedes," which was built in 1840. It was considered so successful that paddles have almost been eliminated in British waters. The first transatlantic screw steamer was the "Massachusetts." By it steam vessels were introduced into Chinese waters. The hulls and machinery of these vessels were sent out from the United States in sailing vessels.

The steamers now commonly in use are usually four or five hundred feet in length, and have a speed of fifteen or twenty miles an hour, using engines of three and four thousand horse-power and consuming about one hundred tons of coal per day, crossing in about eight or ten days. Advances in nautical science have enabled several boats to lately make the trip in about five days.

The "Great Eastern," the largest boat that had ever been constructed, was begun in 1854 and completed in 1859, by

J. Scott Russell. She was built on the Thames, England, and was six hundred and eighty feet long, eighty-three feet wide, fifty-eight feet deep, with twenty-eight feet draught. She was propelled by four paddle wheels and four screws, and was of twenty-four thousand tons measurement. The paddle wheels had a diameter of fifty-six feet, and the screws, twenty-four feet. The steam boilers supplying the paddles had more than an acre of heating surface, while those supplying the screws had much more. She was expected to have a speed of sixteen and one-half miles an hour. Her most important work was the laying of the ocean cables. On account of the great expense in running her, she was abandoned as a regular traveler, and only called on in an emergency. She has now been condemned to destruction, and if she has not already been pulled to pieces she will soon be.

Steam engines in their early years were known as "fire or heat engines," which is really the more proper term for them, because heat is the energy which performs the labor through the medium of water.

Such is partially the story of the origin and progress of steam navigation which has become one of the mighty wonders and triumphs of human patience and ingenuity. By it the steamboat of to-day can "walk the waters like a thing of life," and by its almost universal adoption great strides have been taken toward breaking down the barriers of ignorance and barbarity.

# PHOTOGRAPHY.

PHOTOGRAPHY, that "child of optics and chemistry," is both a science and an art. It is one of the greatest scientific facts of the present day and is not restricted to the mere making of pictures, as commonly understood, but it includes everything coming under its literal meaning: "Writing by means of light." It embraces all processes by which any kind of picture can be secured by the chemical action of light, without reference to the sensitive surface upon which it acts. It delineates objects by the agency of the light which they reflect or radiate.

Observations of chemical changes by the action of light were probably made in pre-historic times, as there has always been the fading of the flowers, the tanning of the skin, and similar natural chemical effects. The Greeks knew that the opal and the amethyst parted with their brilliance in the sunlight. Pliny noticed that wax bleached when exposed to the sun's rays. Other organic substances were observed to change color under the influence of sunlight; some bleaching and others darkening, according to the nature of their ingredients. It is said that the alchemists noticed, as early as the twelfth century, that the chloride of silver blackened by exposure to the beams of the sun. This occurred in proportion

to the intensity of the light, but the change was gradual. Fabricius, in 1556, observed the curious action of sunlight upon the silver compounds, and publicly proclaimed it. He abandoned his work on this line because it seemed to lead him away from gold, for which he was searching, so he did not further pursue his discoveries.

The first germ of photography, as an art, was the experiment of Priestley's. He deposited some chlorides of silver on the side of a bottle made of glass, and put around the bottle a piece of dark paper, out of which some letters had been cut, and exposed the arrangement to the sunlight. The result was that the silver surface protected by the dark paper was white, but the holes had permitted the unprotected part to blacken.

In 1727, T. A. Schultze, a German experimenter, coated paper with a mixture of silver nitrate and chalk. This he exposed to light under a sheet of translucent paper, by which means was obtained a negative, or reversed copy.

Charles W. Scheele, a German chemist, in 1777, experimented to determine whether it was some special colored ray or the whole beam which wrought the change. By means of a prism he dispersed the beam into its rays, and exposing a sheet of paper coated with silver the darkening commenced in the indigo or violet ray and extended far beyond sight. Going in the other direction it ceased in the blue ray, and the green, yellow, orange, and red ones produced no effect upon the silver. Thus was discovered that the sunlight did not darken the silver by virtue of its light alone, but by some other principle which the beam contained. Scheele stated as the result of his experiment that silver salt would blacken as much under violet light in fifteen seconds as under the red

in twenty minutes. There is no doubt that he worked with an imperfect or defective prism, as the subsequent investigations of other scientists have proven that the red rays exert no influence whatever upon the silver salt. He found, furthermore, that the decomposition of the salt into its elementary substances—chlorine gas and silver—was what caused the blackening. By this decomposition the gas escapes, but the silver remains in a finely distributed metallic form. What he discovered has been retained as the basis upon which has been built a theory of photographic printing. The English historians call Scheele a Swede, the mistake arising from the fact that at this time his home, Stralsund, was in possession of the Swedes.

The first instrument to be used in photography is the camera obscura, which Baptista Porta, the Italian philosopher, in 1569, has the honor of inventing. His camera consisted simply, as its name implies, of a darkened room, to which not a ray of light was admitted excepting through a small hole in the window shutter. In a room of this kind, when there is bright sunlight out doors, an inverted, but not very vivid image of external objects within range of the aperture is cast upon a screen placed in front of the window. By fixing a double convex lens in the hole, Porta improved this primitive contrivance and also by adding a mirror so placed on the outside as to catch the rays of light and reflect them through the lens. This caused the image to appear much brighter, more distinct, and in its natural position instead of inverted. This invention was considered a great curiosity, and multitudes flocked to Porta to see these marvelous pictures painted by the sun, glowing with color, and so wonderfully accurate. Improvements in the camera were soon made,

and it became, as we would say in these days, such a fad that it was a favorite adjunct to the country houses of the rich. These were usually in the form of a small circular house, when possible erected specially for it on a hill-top.

It is not known when the first lens was made, nor for what purpose, but amongst the ruins of Nineveh there has been found a double convex lens, showing that it must have been in existence at least a thousand years before the Christian era. This is the first optical instrument of which we have any knowledge.

With the dawn of the nineteenth century and the progress made in chemistry, the times seemed more propitious for the development of the arts and sciences. There is a question about this art which has never been satisfactorily answered, and that is: Who was its discoverer? It is known that in the house of Mr. Boulton, of the firm of Boulton & Watt, a descendant of Matthew Boulton, at Soho, near Birmingham, Eng., who died in 1809, were found a camera and metal plates, about the size of note paper, exactly like those subsequently used by Daguerre in the early days of photography. There were two of these plates, and on each was the faint image of the house at Soho, evidently produced by means of light. All experts examining them immediately pronounced them to be photographs taken by the aid of a camera from nature. In addition to this expert testimony there was attached to them a memorandum stating they were indeed sun pictures which represented the house as it was before certain alterations were made in it in 1799. Thus the discoveries of Niepce and Daguerre were anticipated, but the secret died with him. There has been found the mention of a camera belonging to one of the Wedgewoods in 1791. Investigators

place the dates of the first experiments in photography as early as 1790–91. At this latter date it is known that Thomas Wedgewood, the celebrated porcelain manufacturer, had a camera repaired. He subsequently published his method in the *Journals of the Royal Institution* in 1803. He and Sir Humphrey Davy experimented with paper and leather soaked in a solution of nitrate of silver, which they changed later on for chloride of silver, as they found that to be far more sensitive to the action of light. This was a corroboration of the results obtained by Scheele. Their work proved abortive because they could not permanently fix the impressions secured. This was a difficulty which even Sir Humphrey's superior chemical skill could not surmount. The crying need of the hour was some agent to fix the picture. Many media for this purpose had been proposed and experimented with, but nothing was found to be thoroughly practical until a soda salt was tried. This salt, the hyposulphite, was discovered in 1799 by Chassier, but Sir John Herschel first employed it for photographic purposes in 1840.

In 1814 M. Nicephore Niepce, of Chalons, on the Saone, commenced his experiments in heliography, as he called it. He gave Daguerre the benefit of his extensive experience, and there is no doubt that he was the means of securing for Daguerre the name and fame which have been accorded him. Niepce died in 1833, and on June 14th, 1837, his son, M. Joseph Isidore Niepce, made an arrangement with M. Louis Jacques Mande Daguerre that they should pursue their investigations together and that the results should be for their mutual benefit. Niepce followed his father's process, but did not succeed in making any especial improve-

ment on it, while Daguerre so perfected his theory that the old way was abandoned. Daguerre's process was the making of pictures in the camera upon iodized silver plates. The improvements made upon it soon caused the art to become of practical and commercial value, and its devotees were counted by the thousands. This process was announced publicly in 1839, and the scientific world is said to have been surprised and delighted at the beauty of the pictures he exhibited.

The oldest sun picture in existence is one that was produced by the elder Niepce some time before 1820. It is a carbon photograph and is preserved in the British Museum. "It is on a white metal plate, the clean surface of which forms the lights, and dark bitumen, a substance early found to be sensitive to light, the shadows."

In 1839 Mr. Mungo Ponton proclaimed the discovery that the bichromate of potash was powerfully affected by the rays of the sun when it was spread on paper. A little later Becquerel commenced experimenting upon this salt in combination with organic matters, such as starch and isinglass. He discovered that the mixture formed a film which could be made insoluble in water by exposing it to the light. In 1835 Professor J. W. Draper, of the University of New York, chronicled a series of his experiments in this line in the J. Franklin Institute. He used the bromide of silver and other compounds more sensitive than any others that had ever been employed.

Independently of the discoveries, inventions, and experiments of others, Mr. Henry Fox Talbot, of Lacock Abbey, was led accidentally to try the nitrate of silver process, with which he experimented in 1834. He presented the Royal

Society with a paper, on January 1st, 1839, entitled "The Art of Photogenic Drawing." His early pictures were all negative or reversed, as the light was shade in them, and the shade was light. He secured a patent February 8th, 1841. He called these pictures Calotypes, but the name was changed later to Talbotypes.

In 1848 Niepce de St. Victor, a nephew of Nicephore de Niepce, used a glass plate coated with iodized albumen, but not very successfully. M. Blanquart made it more practical, but it was perfected by M. Le Gray. Waxed paper was afterward introduced by Le Gray, which became a great favorite. This paper was rendered translucent by the use of white wax. He also suggested the collodion process, though it was left for Archer, of London, to make it a practical success.

In 1855, M. Poitevin, of Paris, made the next important advance in the art by producing the first photographs in pigments. His description, deposited with the Prefect of the Seine, is as follows: "I apply various liquid and solid colors to paper, cloth, glass, and other surfaces, by mixing such colors with the compound of a chromate or bichromate and organic matter and applying the new mixture to the paper or other surface. The photographic impression is produced upon this prepared surface by the action of light passing through a negative photographic picture or other suitable object or screen, and it is then washed with a sponge and a large quantity of water. The albumen, or other organic matter, is rendered insoluble at the parts where it has been acted upon by the light, and the design is thus reproduced in the color which has been employed." But others, not knowing of his process, reached the same results. In those pic-

tures there was a deficiency of half tone, and they had not that delicacy to which the public had become accustomed in the photograph. After long discussion and many trials the desired result was reached by printing on one side and washing on the other, so that the thin, insoluble surface that would naturally form the half tones should not be washed away. This method was at first thought to be almost if not quite impossible, but the feat was accomplished by a Mr. Swan, of Newcastle, one of a firm of noted chemists and makers of photograph materials in that town. His process is to coat the paper evenly with gelatine, sugar, and the coloring pigment. For this he has a specially contrived machine and is able to do it on a large scale. He next renders the surface sensitive by drawing it through a solution of bichromate of potash and exposes it in the usual way behind the negative. The results of the exposure are not visible, nothing but a sheet of shining black paper, from which the picture has to be brought by washing, not the exposed surface, but the reverse. To accomplish this he cements the paper by means of an India rubber solution, face downward, upon another sheet of paper and lets the cement dry. Then it is immersed in water, the India rubber protecting the impressed surface of the film, but the water soon penetrates the other paper, softens the gelatine under it, and permits the removal of the first paper. This leaves the back of the film exposed. It is then thoroughly washed until the unhardened parts are all cleansed away, and the picture stands forth in all its loveliness; high lights, delicate middle tints, and deep shade, as accurately fixed as in the finest silver printed photographs. The image is now reversed, so it becomes necessary to remount it in its first position. This is done by coating with

pure gelatine and pressing it on to the card which is to finally receive it. Then it becomes necessary to remove the India rubber paper which is now on top. For this a little benzole is used which dissolves the rubber without injury to the gelatine, and when the loosened paper comes off the picture is finished. This is a less troublesome and a much cheaper process than the ordinary photographs. These pictures are also very permanent. The work of simple photography is marvelous, but it is thought that the multitude of pictures secured by photegenic action, both in form and material, goes beyond the category of marvels and is considered almost miraculous. India ink sketches are reproduced in India ink, sepia, in sepia, red chalk, in red chalk, etc. These prints are called Autotypes, and it has been well said of them: "Surely this is the greatest triumph that any productive art has yet achieved." By means of these pictures and a small outlay of money the works of the great masters may be studied.

Previous to 1854, all photographic work had been done with moist plates, or plates freshly prepared. This made the *impedimenta* for field work very cumbersome. In *La Lumiere* of April 22d, and May 27th, 1854, M. Gaudin describes his researches and experiments with dry plates. In August of the same year Mr. Muirhead, of England, announced that light acted almost as satisfactorily on a dry surface as on a wet one. Dr. Taupenot, however, seems to have been the first one to use a dry plate to advantage. These plates have been so improved that photographs can now be taken in the merest fraction of a second. By their employment flash-light pictures have become a possibility. These lights are produced by scattering powdered magnesium into a lamp flame.

The forms of these lamps are many and ingenious. They are usually spirit lamps, having connected to them a receptacle for holding the powdered magnesium, with a pneumatic ball and tube attached. By pressing the ball, a puff of wind drives the powder into the blaze. This light is used for taking interiors and other places where sunlight is not available.

A most valuable improvement in all dry-plate processes was the introduction of the alkaline developer. It is of American origin, being used by Major Russell, in 1862. By its use the development of the plates is greatly accelerated.

In 1864, Bolton and Sayce published the germ of the collodion emulsion process, which greatly simplified the photographic work of that time. Gelatine was substituted for the collodion by Dr. R. L. Maddox, in 1871. This process was improved through the experiments of several men until it reached a high state of perfection, and is the best now in use where glass plates are employed.

Films are the most recent improvements in the sensitive surfaces used in photography. By them the art has been well-nigh revolutionized. Mr. Woodbury, in 1876, invented a material as transparent as glass. He combined collodion, castor oil, and Canada balsam, which he spread and dried on a sheet of glass. An emulsion coating which was sensitive to the light was next applied, and after drying thoroughly the sheet of the compound was stripped from the glass and cut into requisite sizes. By its flexibility, it modified the whole business of changing plates, as this could now be effected by a handle on the outside of the camera. A Mr. Warnerke took up the same idea a few years after, and patented a roller slide on which strips of these films could be operated in the instrument.

Messrs. Morgan & Kidd first applied a gelatine emulsion to paper which has become known as bromide paper. It is chiefly used in enlarging, though it was originally intended to use it for negative work, as the paper was subsequently rendered transparent. The Eastman Company introduced a film of excellent quality, which they wound on spools to be inserted in the camera. When the strip had been entirely used, it was taken out, the negatives separated by cutting them apart, and then they were made translucent by a preparation of vaseline.

Transparent and flexible celluloid has brought photography to still greater perfection. This substance was invented and proposed for photographic use by Parkes, in 1855, but as collodion dissolved it, it could not be employed. Being insoluble in water it makes the best backing for a gelatine film. It is now made nearly as clear as glass and is the best thing yet introduced. It is made thin enough to be wound on spools and used in roll holders. While it costs more than glass it is very generally used. Its advantages are that it is not fragile, but light and portable, and free from the halations, or blurrings, which are caused principally by reflections from the back surface of glass.

Photographic lenses are of two kinds : those used in taking portraits, and those for views. The portrait lenses are of large aperture but give a small image, while the view lenses have a small aperture but give a much larger image. There is a portrait lens called a doublet, by which views can be taken. Generally, however, views may not be taken by portrait lenses, but portraits, under some circumstances may be taken by the view lenses. The single view lens is the cheapest, and for views alone has not been excelled.

Photographic lenses have been improved in various ways. Aluminum is now used for their mountings instead of brass, which reduces their weight. The lens diaphragms have also been improved by a contrivance which expands and contracts like the iris of the eye. For this reason it is called the Iris lens. This arrangement consists of several flat blades or tongues of thin, blackened metal, which are fastened to a ring in the lens mount. By turning this ring, expansion or contraction is caused, thus increasing or reducing the aperture as desired. By the use of the Jena optical glass in these lenses, a larger field can be covered with a given aperture than formerly. The first great improvement upon Daguerre's process was in the use of enlarged lenses, by means of which Mr. Draper, of New York, was the first to secure portraits from life.

Improvements in the printing of photographs have kept pace with those of the other departments, and there seems to be little left to be desired in this noble art.

As a description of the largest photograph in the world, on exhibition at the Columbian Exposition, may be interesting to many, it is inserted: "D. R. Day, of the Standard Oil Company, has placed in position the largest photographic transparency ever made. It is seven feet long and fifty inches high, and is a photograph of a relief map of the United States, showing the oil-bearing districts. Photographers stand before the colored transparency, in the north gallery of the Mines building, and declare it to be the biggest thing in the Exposition, and so it is, from their standpoint. J. K. Hillers, of the United States geological survey, is the man who made the wonderful photograph. He is known among his craft as the best photographer on large work in the country, but he

distinctly affirms that money cannot tempt him to even attempt to make another seven-foot picture. Enlarged bromide prints on paper have been made that came within half a foot of the Standard Oil Company's photograph, but to place a photograph on a piece of plate glass which could fill up a seven-foot window has heretofore been deemed impossible.

"The model relief map was started three years ago. It is made of wood veneers, one-thirty-second of an inch thick, each thickness representing one hundred feet of elevation. The map was built up of these veneers, and then carved in relief and a plaster cast taken. With the light striking it from the northwest, it was photographed, the lights and shadows giving it a beautiful tone. When the negative was transferred to paper, the States, lakes, and names were drawn in, and a negative was taken from it twenty inches square. This negative was enlarged to the size of the transparency, twenty-four inches by fifty inches.

"No ordinary camera could do the work, so the photographer made a camera of a room twelve by fifteen feet in size. The room was blackened inside and made light and even air tight. The shutter was placed in the window and the lens in the shutter. Mr. Hillers had three expert photographers assisting him in the work, and they built a silvering vat which used two hundred and fifty dollars worth of nitrate of silver, and a developing vat, both in the gigantic camera, so that probably for the first time the camera itself was used as the developing room.

"The work was focused on a ground-glass plate, the same size as the photograph. This was done by three men holding the plate and moving it back and forth until the proper focus was secured. Then the sensitive plate was made ready.

This was a piece of American plate-glass, three-eighths of an inch thick, made and polished for this particular picture. The photographers had to wait two months for proper conditions of light and temperature. A work of this nature had never before been attempted on such a large scale. Mr. Hillers was obliged to feel his way, for he did not know just how long the plate should be exposed. A test was first made with a small plate, and this gave him an approximate measure of time.

"With rare good fortune, the first exposure of the new plate was a success, and a beautiful photograph was secured. Then a specially arranged hose was turned against the big plate to wash away the chemicals. It took an hour to do this. After the toning process came the matter of varnish. This was the critical phase of the operation. The plate was laid on four rubber balls, one at each corner, and Photographer Hillers tilted it while an assistant poured on half a gallon of varnish. Success still remained with him, and the transparency was ready for its colors.

"The oil-bearing districts are shown in yellow, and each particular region where oil is actually brought to the surface is shown in the color of the oil itself. It took four months from the beginning, when the first negative of the map was taken, to finish the transparency. It is valued at five thousand dollars."

The next largest photograph is also on exhibition at this World's Fair. It is in the northwest corner of the Manufacturer's building. It measures five feet in length. The subject is a trade name, in very large letters. The stem of each letter is decorated with the figure of a little child. Each figure is quaintly and differently costumed, which makes a beautiful combination. New South Wales has the finest com-

plete collection of photographs at the Exposition. Those of this country in the Liberal Arts building show the best features of New South Wales, its cities and landscapes.

Perhaps the progress of the art from its first inception to the present time will be best appreciated by comparing the lengths of time required for exposure of the plates in each process.

Daguerre's process originally required thirty minutes.

The calotype, or talbotype, requires two or three minutes.

The collodion process takes ten seconds.

The collodion emulsion process takes fifteen seconds.

The rapid gelatine emulsion process requires one-fifteenth of a second.

Films require one-thousandth of a second.

Think of it, ye rapid, eighteenth century Americans! What a penalty our grandmothers had to pay for their vanity! Would it be possible for us to sit quietly long enough to have our daguerreotypes taken?

The extent of the utility of the art will never be measured, except by the demand. All divisions of the arts and sciences are served by it. By the wedding of the camera and the telescope sidereal photography has become a possibility. The photographer presents to nature a retina far more sensitive than that of the natural eye. It correctly records the most rapid motions of life, as a trotting horse, a moving train, or the dust of an approaching cyclone.

From the time of the alchemists' search for gold, which opened up the paths for modern chemistry by its accidental discoveries, to the present day and stage of its perfection, photography has steadily progressed until it holds an undisputed place among the foremost of the arts.

## SEWING-MACHINES.

AS far back in the beginnings of time as when Adam and Eve held a monopoly of all the arts and sciences, the accomplishment of sewing was ushered into existence. In the most authoritative account which has come down to us of the doings of our first parents, it is related that they sewed fig leaves together to make themselves garments. The primitive simplicity of their costumes has long since been discarded by the men and women of civilized communities, and with the advance in complicity of attire has kept pace development in the art of sewing.

For ages upon ages all sewing and embroidery was performed by slow, laborious hand processes, and no thought of more rapid achievement by the use of machinery seems ever to have been dreamed of by the painstaking toilers with the needle. Marvelous, truly, have been the fabrics so skillfully wrought in ingenious devices, but great and wasteful have been the time and labor expended upon them. That no one should have thought of the application of machinery to the making of garments is indeed surprising; but it had been employed for centuries as a substitute for almost every other form of handwork before any attempt was made to construct a sewing-machine.

The first essays to make a machine for sewing aimed at the imitation of hand sewing, using but a needleful of thread, and making a running through-and-through stitch. It was found, however, that this was impracticable for many reasons, among others, because of the wear on the thread—and so inventors sought to form by means of machinery the old crochet stitch. Until Elias Howe, in 1844, invented the lock stitch, made by a shuttle, the sole use to which sewing-machines were put was to embroider, while anything in the shape of a sewing-machine was unknown a hundred years ago.

Charles F. Weisenthal, in 1755, invented and patented a double-pointed needle for hand embroidery. The needle had an eye in the centre, and was to be manipulated by holding it in the middle with the fingers in such a way that it should not require turning. This invention may be perhaps regarded as the first step toward the invention of a sewing-machine.

In the latter part of the last century, and the first of this, several inventions foreshadowing the machine of later date were made. In 1790 an Englishman, Thomas Saint, was granted a patent for a machine used in making shoes. This resembled in some important particulars the modern sewing-machine. By means of a needle and a series of hooks this machine made a single-thread chain-stitch. For some reason the invention of Saint never came into general use. In 1804 a French patent was granted to Messrs. Stone and Henderson for a machine designed for the making of wearing apparel; but this, too, failed of general adoption.

After several other but partially successful ventures, a Frenchman named Barthélemy Thimonnier, a poor tailor of St. Etienne, invented, in 1830, a wooden crochet sewing-machine. Having patented it, he organized in 1841 the firm of

"Ferrand, Thimonnier, Germain Petit et Cie." He succeeded in interesting in the enterprise a government engineer, who was clever enough to perceive the great value of the invention. Through the influence of this friend, a factory was opened in the Rue de Sèvres, and eighty wooden machines were set in motion for the making of army clothing by contract. But jealousy and ignorance induced an angry mob to make an attack upon the establishment, destroy the machines, and force the unhappy inventor to take refuge in flight. Beaunier, the government engineer who had assisted him, shortly after died, and Thimonnier, reduced to poverty, was compelled to make his way back to his native place, St. Etienne.

Not wholly discouraged, he still continued to work at his invention, and in 1848 he produced a model much superior to his first machine, the last one being of metal instead of wood, as formerly. Through the aid of M. Maguin, of Villefranche, he obtained a patent in England, and this time he sold the patent to a Manchester company. In this instance, as is usually the case, the public were slow to appreciate the merits of a new invention. A workshop was established in Paris, but was destroyed in the Revolution of 1848. Misfortune continued to befall the persevering inventor, and after battling for many years with adverse fate, he died in poverty in 1857. Thimonnier's machine used a hooked needle and made a chain-stitch. It is still regarded as a remarkably clever invention, and one which should have conferred better returns upon its originator.

Among other machines which followed Thimonnier's invention was one for producing ornamental stitching upon gloves, which was produced by Edward Newton and Thomas Archbold. In this the needle worked under the material, forming

an inverted chain-stitch. The machine had six needles, which made six rows of stitches. One of the machines patented in America was adapted for working in leather, and was the invention of John Greenough. It was patented in 1842. Another American machine was designed by Leonard Bostwick. The peculiarity of this machine consisted in its having a stationary horizontal needle, against which the cloth, after being crimped by toothed wheels, was passed. The result was a running stitch suitable for joining laces, or other loose sewing.

It is not until December, 1844, that we find a patent granted to any one for a lock-stitch machine. In this year, John Fisher and James Gibbons invented and patented a sewing-machine, operating by means of a shuttle, which carried thread, gimp, or cord. The shuttle was given a reciprocating motion, so that it came between the thread and the bent part of the ascending needle, by which movement it left its own thread to be caught down by the needle in its descent. This machine was designed for working patterns on fabrics. The same inventor, at the same time, patented a machine for embroidering. The inventor of these machines, John Fisher, of Nottingham, was at that time a young man, but nineteen years of age. The shuttle machine, which he had originated, in all unconsciousness of the future usefulness which lay hidden in his invention, was later developed into a sewing-machine. But the young inventor confessed that he had not in his own mind any thought of constructing a sewing-machine, and was not aware that he had done so.

It is to Elias Howe, Jr., an American born at Spencer, Mass., in 1819, the son of a farmer and small mill-owner, that the honor of being the inventor of the first sewing-machine

capable of successful and practical operation, is generally conceded to belong. In 1835, young Howe went to Lowell to serve with a manufacturer of cotton machinery, at the munificent salary of fifty cents a day. By the financial panic of 1837, he was deprived of work, and going to Cambridge, Mass., he obtained a position in the shop of a Boston machinist, named Ari Davis. In the quiet hours snatched from this occupation, there first occurred to him the idea of making a sewing-machine. Once the thought had obtained a lodgment in his mind, every leisure moment was devoted to his darling project. For five years he planned and devised, at the end of that time, in May, 1845, produced a model of a sewing-machine. This, owing to his poverty, he was enabled to do only through the pecuniary assistance of an old school-mate, George Fisher. With this friend he formed a partnership, and in September, 1846, he secured a patent for the first practical sewing-machine.

But the path of the inventor is by no means strewn with roses. The artisans of Boston, bitterly opposed to any form of labor-saving machines, refused to make use of the invention, and Mr. Howe was forced to seek employment as an engineer on the railroad. His health failing him, in this occupation, in 1847 he made a visit to England, in the hope of finding there a more favorable reception for the masterpiece of his genius. All in vain. No better success awaited him there, and without even money to pay for a return voyage, he worked his way back to the United States as a common sailor. During his stay in England, he had disposed of his rights in the invention, in that country, and had made changes in the machine adapting it to work in corset, umbrella and valise manufacturing.

On his return to the United States, he found that unscrupulous persons had not hesitated to take advantage of his absence to construct imitations of his machine, regardless of the patent, and sell them throughout the country. Through the assistance of friends, he finally, after many appeals of legal interference, secured the recognition of his first right to the invention. This was a long stride toward prosperity. Success, so long eluding him, was now fairly within his grasp. In the course of a year Mr. Howe was able to repurchase all of the patents on his machine which adversity had obliged him to part with. On every sewing-machine that was manufactured in the United States after this he received a royalty, and the struggling inventor living on an income of three hundred dollars a year, became in a few short years the affluent manufacturer whose yearly income amounted to two hundred thousand dollars. Everything bent before him now. At the expiration of his patent in 1867, it was estimated that he had netted about two million dollars from his invention. He had organized in 1863 a company of which he was president, for the manufacture of sewing-machines. This company erected a large factory at Bridgeport, where an extensive business was carried on.

During the civil war Mr. Howe enlisted as a private soldier in the Seventeenth Connecticut Regiment, serving in this capacity until failing health obliged him to resign. He rendered still further aid to the government, in the shape of an advance of money to pay the regiment, when the government was pressed for funds. Many medals were conferred on Mr. Howe, in recognition of his great achievements. At the World's Fair in Paris in 1867, he was given the gold medal, and likewise the cross of the legion of honor.

It is often difficult to say just how much one person is indebted to others for the ideas which lead to his attainments. Equally perplexing is it to decide always to just which one of several competing inventors belongs the credit of having been the first to grasp and make material the happy thought. It is, therefore, not surprising that there should be those to contest the honor ascribed to Elias Howe as the originator of the modern sewing-machine. It is claimed by some that Walter Hunt, of New York, was the true inventor, and that Howe's priority was only in the obtaining of the patent.

Walter Hunt is said to have constructed, between 1832 and 1834, a sewing-machine in which an eye-pointed needle fixed to the end of a vibrating arm carried a thread through the cloth, forming a loop, through which moved a shuttle bearing another thread, the result being a stitch now known as the lock-stitch. In 1854, Mr. Hunt applied for a patent for his machine, but this was refused him on the ground that all of the chief features of his invention had been previously patented by Mr. Howe. It was held that the right of Hunt to a patent had been forfeited by abandonment. It is, of course, possible that had Mr. Hunt entered an application for a patent some years earlier, Mr. Howe might have been compelled to share with him the honors which he now wears alone. But be that as it may, no one will certainly deny that the rewards which the lucky aspirant gained were justly due to the energy and perseverance which marked his entire career as an inventor.

Sewing-machines are classified according to the form of stitch produced by them, as the "chain-stitch," "double-loop," "lock-stitch," and the "buttonhole-stitch" machines. In the chain-stitch machine but one thread is used, and

this is looped upon itself by means of a curved needle or hook moving beneath the fabric. This curved needle catches the thread, as it is passed through the cloth, in the eye of the vertical needle, holding it until the needle again descends through the thread loop thus produced. The vertical needle rising, draws this loop up on the lower side of the cloth, and by these successive ascents and descents of the needle a chain of stitches is formed. This stitch is raveled with facility by merely taking hold of the thread after it has been drawn through the loop, much as knitting is raveled. Because of this quality of raveling, the chain-stitch machines are disliked by some sewers, and for certain manufacturing purposes they are manifestly unsuited. But this very feature renders this often a most convenient machine for domestic use, where the housekeeper of moderate means regards the remodeling of garments an important branch of the family sewing. An illustration of this class of machines is the Wilcox & Gibbs, an old and well-known make.

Two threads are employed in the double loop-stitch machine, one placed above, the other below the cloth, the upper thread being passed through the eye of the vertical needle, while the lower is threaded into a circular needle vibrating just underneath the fabric. The vertical needle descends, carrying the upper thread with it, down through the goods, to be here caught by the under thread, with which it is looped and interlooped. A stitch is in this way formed which is interlooped with the stitch next to it, giving, on the under side of the cloth, the appearance of three threads, while the upper side presents the same single-thread stitch of the chain-stitch machine. This stitch, drawn firmly to its place, makes a durable and strong stitch, well adapted to either plain sew-

ing or embroidery. This is the stitch of the Grover & Baker machines. These machines use a large quantity of thread, and the stitch, like the chain-stitch, is easily raveled. This stitch is still retained in machines of recent manufacture, although the Grover & Baker, the machine originally producing it, is no longer made.

About four-fifths of all the sewing-machines now used are constructed after the lock-stitch, or, as it is sometimes termed, the double lock-stitch pattern. The stitch in all these machines is the same, and is formed on substantially the same principles. The lock-stitch is a double-thread machine, with one thread above and one under the fabric. The stitch is in every instance produced by passing one thread in the eye of a vertical descending needle through the cloth, and then, through the loop thus made, passing another thread, usually carried by a shuttle. The needle, in its ascent, draws the under thread upward, and the two threads are securely interlocked in the cloth, making a stitch than which nothing could be more serviceable or durable. This stitch does not ravel.

There are many different kinds of machines employing the lock-stitch, but they may be classified into two large divisions, distinguished as those having the vibratory, oscillatory, or shuttle movements, and those made wholly on the rotary motion principle. The Singer and the Wheeler & Wilson machines are the two makes of sewing-machine which best illustrate the two kinds of lock-stitch, being the two in most general use. Other lock-stitch machines, of which there are many high-grade varieties manufactured, are the Remington, the Howe, the Florence, the Weed, the Domestic, the American, and others less widely known. All of these alike form

the lock-stitch on the principle of the vibratory or oscillatory shuttle motion, or on that of the rotary motion.

The Singer machine had originally a vibratory or reciprocating shuttle, which supplied the lower thread to the machine. In 1878 the company adopted the oscillating shuttle. This shuttle has a long beak, and is so placed as to seize and hold the loop until the needle ascending is free from the cloth. While the needle is raised the shuttle passes through the loop, pulling the thread down through the eye of the needle. Much strain upon the thread is avoided by this device, the opening in the cloth allowing the thread free movement.

The Wheeler & Wilson machines are constructed on the rotary hook principle. This consists of a rotating hook, made by a disc of polished steel, with curved, pointed ends, and a slot cut in the periphery. This disc being attached to a horizontal pulley shaft, which revolves with it, casts off from its edge each time that it revolves a loop made by the upper thread on the outside of the needle, passing downward through the slot. The rotating hook catches this loop, and draws it with it part way around, and, on its being slipped off, the thread is a second time partially lifted by the ascending needle. The thread crosses the bobbin, interlocking with the bobbin thread, forming loops, which, lightly drawn up, produce the lock-stitch. The bobbin revolves in an opposite direction from the hook, and is fitted on the outer side of the rotating hook in a concave holder. In this way the correct tension is secured, while the proper length of thread for each stitch is measured off.

The stitch of the buttonhole-stitch machine is in substance a lock-stitch, in which the under thread is carried up upon the edge of the buttonhole. This stitch can be produced by

means of an attachment applied to an ordinary machine. The buttonhole-stitch machine works automatically, cutting its own buttonhole, which it works either before or after it is cut. It cords the buttonhole and bars the end, and when the work is completed stops automatically. This machine is a marvelous piece of workmanship, seeming to be endowed with something like intelligence in its action. One of these machines will work six thousand buttonholes in a day; fifteen hundred stitches per minute being the rate of speed. They will work on any kind of goods, from the finest cambric to the heaviest leather.

Many fancy stitch machines have been manufactured which can do back-stitching, basting, over-and-over sewing, hem-stitching, and, in fact, almost every stitch known to the doer of hand needlework. The ordinary machine has now attachments for doing hemming, binding, ruffling, quilting, tucking, braiding, and other forms of work, which the earlier inventions made no attempt to perform. New additions are being constantly made to the varying execution of all machines, so that the instrument of a year is found lacking beside the one completed to-day.

The machines as first invented by Mr. Howe had one great defect, which was exhibited by all sewing-machines of that and later times. There was no way of moving the cloth along without interfering with the operations of the needle. Many attempts were made to remedy this difficulty, such as a needle vibrating vertically, and thus moving the fabric along; but none proved wholly successful.

Mr. A. B. Wilson, in 1851, finally invented and patented a device known as the "four-motion feed," which exactly met the want. This apparatus consists of a serrated bar which

moves in a slot in the horizontal plate on which the cloth is fed. The four motions are an upward, a forward, a downward, and a backward motion. By the upward motion the teeth of the serrated bar are fastened in the fabric, the forward motion moves the cloth forward, the downward motion causes the teeth to lose their hold, and the backward motion consists of the horizontal passage of the bar backward beneath the plate, in position for a repetition of these movements. The motion by which the cloth is carried forward is timed by eccentrics upon a wheel, or by other means, so that it occurs while the needle is raised, thus escaping interference with the passage of the cloth. Mr. Wilson's invention has since been adopted by all machines for flat-bed work. By the operation of this four-motion feed, the cloth may be turned in any direction without stopping the machine, an improvement greatly expediting and otherwise facilitating sewing. In the Wilcox & Gibbs machines the four motions are secured by a single eccentric, and an invention has been produced by which the number of stitches to the inch may be determined.

Although not half a century has passed since the sewing-machine became practically useful, there is now no machine in more general use. The economic effects of this invention can scarcely be overestimated. Entering as it does into so universal a domestic occupation as the making of clothing, it reaches all classes. It has given rise to an entirely new industry, the sale of ready-made clothing. And in this case, as in other instances where machine work has been substituted for hand-work, the result has been ultimately a great cheapening in the price of the finished product. Best of all, it has brought to the over-burdened woman, too closely wedded to

her needle, the more abundant leisure that bespeaks great good both for body and mind. Where weeks were formerly consumed in the making of garments, as many days will now accomplish far more satisfactory results.

True, it is asserted that with the gain in rapidity of work, attained by the sewing-machine, has come elaboration in clothing to counterbalance it, that modern æsthetic taste refuses to be satisfied with former simple fashions. There is doubtless much truth in this, but it is only what takes place with advance in any department of industry. The progress of civilization brings increase of wants on all sides. There is no limit to human desires. And with the satisfying of these ever-multiplying desires, comes a fullness and broadness of life which we sum up in the term civilization. All inventions pave the way, indeed, to more wants, but also to greater satisfactions.

# PRECIOUS STONES.

"Thou hast been in Eden, the garden of God; every precious stone was thy covering, the sardius, topaz, and the diamond, the beryl, the onyx, and the jasper, the sapphire, the emerald, and the carbuncle. . . . Thou hast walked up and down in the midst of the stones of fire."—*Ezekiel* xxviii, 13, 14.

PRECIOUS stones, those "flowers of the mineral kingdom," as they are most appropriately called, have been, from time immemorial, the symbols of power, beauty, and excellency, and they abound in the imagery of Holy Writ. They have figured prominently in the affairs of individuals and nations, and have been the inciting cause of intrigues, wars, and crimes. The course of their wanderings has been marked by deception, theft, and murder. To put it most mildly, they have been the occasion of a vast amount of exaggeration. They were venerated by the ancients and endowed with many supernatural attributes. They were not confined alone to the imagery of Scripture, but play a prominent part in its reality, as the breast-plate of the priests and the reputed wealth of various kings and nations attest.

Precious stones are disseminated throughout the entire world. They are found in the torrid deserts of the Dark Continent, on the icy steppes of Siberia, in the tropical heat of India and the Island of Ceylon, amidst the glaciers of

Switzerland, and the river beds of South America. Germany and Spain, as well as North America, contribute their quota. But the tropical countries seem to be most prolific.

In all the boundless wealth of nature there is nothing which has proved so fascinating to man, from time beyond the reach of history, as brilliancy. So it should not excite surprise that precious stones, those "flowers of the rock" to which is added the crowning gift of durability, should have inspired so much admiration, not to say veneration. To these peerless little objects was ascribed a spiritual, as well as material power, ability to cure disease, avert calamity, and drive away bad demons, and render the possessor invulnerable and invisible at will. The philosophers—Plato and others—believed that the minerals, animals, and plants were all living beings. Theoprastus, the pupil and friend of Aristotle, wrote a treatise on precious stones, but the entire manuscript is not now supposed to be in existence. He attributed sex to them, distinguished by their brilliancy. The dullest were the female; the brightest, male. Dioscorides, in the first century of the Christian era, wrote concerning precious stones. He fully develops the idea that they possess a multitude of secret virtues, which is even yet believed by many. These tiny bits of the commonest materials, these mere crystals of the most ordinary clays and earths, men reputed to be very wise, as the world counts wisdom, have considered far more precious than liberty, or even life.

It is the rarity, beauty, and durability of a stone which constitute its preciousness. The market for gems is subject to many vicissitudes, mainly from the caprices of fashion. Each, perhaps with the exception of the diamond, has, in turn, been abandoned for a time in favor of some new favorite. Upon

their introduction again to favor, they usually come under a new name, as "The Uralian Emerald," or the "Cape Ruby," etc. The beautiful qualities of very few of the gems are apparent when they are first found. This is particularly true of the brilliant ones. These concentrated treasures of the earth most commonly appear as water-worn pebbles, roughened and indented by the attrition and blows received during the years, and even centuries, of their pilgrimage upon the earth. But few are found in their native bed or matrix, but have traveled by means of flood and other natural agencies, often far from the place of their formation. There is, probably, nothing so difficult to satisfactorily describe as a beautiful gem, as the nomenclature of colors, etc., required is neither adequate nor accurate.

There is no decay to gems. They may lie buried for centuries beneath volcanic lava and ashes or other detritus, be incarcerated in the grasp of a mummy, or awaiting their discovery in their own native beds, but when finally exhumed they still gleam in their original splendor and magnificence.

The Jews entertained many strange superstitions regarding the mysterious influence of precious stones. They foretold future events by the change in color or brilliancy. For this purpose they used twelve precious stones on which were engraved as many anagrams of the name of God. In the Talmud it is stated that Noah derived all the light he had in the ark from precious stones. Gyges, King of Lydia, is said to have had a ring by which the wearer was rendered invisible. He died 680 B. C.

The ancients believed there was a mysterious sympathy between the seven planets and seven of the precious stones; the Turquoise had relation to Saturn; Carnelian to Jupiter,

Emerald to Mars; Diamond, the Sun; Amethyst, Venus; Lodestone, Mercury; and Crystal, the Moon. There was also supposed to be a similar relation between the months of the year and the precious stones.

January—Garnet, for constancy and fidelity.
February—Amethyst, sincerity.
March—Bloodstone, courage, presence of mind.
April—Diamond, innocence.
May—Emerald, success in love.
June—Agate, health and long life.
July—Carnelian, contented mind.
August—Sardonyx, conjugal fidelity.
September—Chrysolite, antidote against madness.
October—Opal, hope.
November—Topaz, fidelity.
December—Turquoise, sincerity.

In the olden days, precious stones were considered the most acceptable offerings to the gods, and the temples and shrines would be the objective point of the marauder in times of conquest and war, on account of the vast accumulation of wealth in them.

Precious stones, being one of the factors in the world's wealth, have a literature exclusively their own, but there is much to be learned of them through general literature, as well as from works which are exclusively scientific.

## DIAMONDS.

These glorious, mysterious gems, surpassing all others in hardness and brilliancy, take first rank among the precious stones. The diamond is aptly called the "king of gems," for there are none which excel, and very few, indeed, which can even approach its loveliness.

The Greeks attributed the origin of all precious stones to their gods. Fantastic notions constituted the general belief regarding the origin of gems. Those pertaining to each will

be noted in its account. The youth who rocked the cradle of Jupiter on the island of Crete was transformed into the "adamas," the Greek for diamond, and fell to the ground amid lightnings and thunder.

The diamond is commonly found in connection with gold, and Plato described it for this reason as like the kernel of the gold, and he supposed it was the noblest and purest part which had become condensed into a transparent mass. The Greeks thought that rock crystal was a congelation, like ice, and could only be found in the coldest regions. They called these crystals "unripe diamonds," and the real gems "ripe diamonds."

There are six kinds of diamonds: Ethiopian, Indian, Arabian, Macedonian, Cyprian, and the Siderite, which last resembles polished steel. There have also been diamonds found in the United States, but not so plentifully as to establish a special class. Diamonds are found in all colors, even black, but the tints are usually very light. While a very large portion of the diamonds found are white, a perfectly colorless transparent gem is rarer than would be supposed. The application of heat will modify their colors, sometimes permanently, and sometimes they will, after a time, return to their original condition. As yet, there has been no satisfactory theory advanced for this variety of tints, and Nature still keeps her secret not only of the forming of the diamond, but its tinting, intact. It is thought that the yellow diamond has the greatest variety of tint. Rose-colored ones are not numerous, but the deep, rich red ones are extremely rare. A few only of these latter are on record. The Emperor Paul, of Russia, bought one for one hundred thousand roubles. It weighed ten carats. There are several specimens

of the other reddish shades to be found in the different collections of Europe. Blue diamonds are nearly as beautiful and rare as the red. These gems differ from sapphires in the quality of the tints and the play of colors peculiar to the diamond. Unless some have been found lately in Brazil or South Africa, the only ones known were found in the old mines of India. Green diamonds are also of various shades, but the pure emerald or grass-green hue is very rare, but when found it surpasses the brilliancy and fire of the finest emeralds. There is one in Dresden which has been considered "one of the five paragons among all the gems of the world." It is supposed that an American amateur of precious stones owns the finest specimen of green diamond ever found. Black diamonds are exceedingly rare. One was exhibited at the London Exposition in 1851, which was the admiration of all experts, because of its size and color. It is a wonderful gem, weighing three hundred and fifty carats, and of a coal black hue. Others of a brown hue have been found, and occasionally those of a cloudy or milky appearance, like opals, are discovered.

Diamond mines consist generally of mere diggings and washings of the mud of rivers. The loose earth containing the diamonds lies always a little below the surface, toward the lower outlet of broad valleys rather than upon the summits of the surrounding hills. It is supposed that diamonds have a volcanic origin, and were thrown forcibly out in some convulsion of nature and scattered broadcast much in the same way as a spray might be on a smaller scale. Some have thought them to be the crystallization of petroleum, with which the matrix was saturated during the coal period. Newton advanced the idea that they were of an unctuous sub-

stance which coagulated, and subsequently crystallized. Other eminent philosophers have held the same opinion. Sir David Brewster believed the diamond was once a mass of gum, which came from a species of wood, crystallized in the processes of nature. It has been thought to be of more recent origin than gold, for some specimens have been found containing that precious metal. The possibility has been suggested that it is still in the process of formation, with capacity for growth. But all this conflict of opinion has not resulted in a definite knowledge of its origin. The matrix, in which the gem is found, seems to vary in different countries. In India it occurs in a sort of sandstone breccia or "pudding-stone," consisting of horneblende, jasper, chalcedony, and quartz, cemented together by a silicious substance. This conglomerate, broken into loose pebbles, forms the diamond fields. In Africa and Brazil jasper, granite, itacolumite, and peridot are indicative of the presence of diamonds. In Australia its associates are shales, trap-rocks, sandstones, and conglomerates. Agassiz believed that the formation bearing diamonds was the glacial drift.

The remarkable brilliancy of the diamond is thought to be due to its great reflecting power, as it throws back all the light falling upon it at a little more than an angle of twenty-four degrees. The beautiful play of colors, peculiar to the diamond, comes from its refractive and dispersing powers. It is this blending and scattering of the rays of light which causes the "fire" for which the gem is noted, and for which it is incomparable. The perfectly colorless specimens presents this interesting phenomenon in a much greater degree than the other varieties. It has been found that these prismatic colors are more vivid under artificial light than they are

under the sun's rays or any other natural light. In 1664 Robert Boyle described the phosphorescence, or its property of shining in the dark after being exposed to sunlight. This property is confined to certain stones, though it is said that it may be generated by steeping in hot water. Graphite and charcoal are the most active conductors, while the diamond, composed of the identical chemical constituents, is a non-conductor of electricity. It acquires positive electricity by attrition, both when in a natural and a polished condition, in which respect it differs from most other precious stones, which are negative if rough, and positive only when polished. It is impossible to dissolve it, or, indeed, to affect it in the slightest degree by the strongest acids known to chemistry. Before the middle of the fourteenth century it was believed impossible to destroy it by fire, but the fallacy of this belief has since been proven.

One great point in favor of its vegetable origin is that its first cousins, the graphite and charcoal, are known to be the result of plant life. Why, then, should not the diamond, pure, crystallized carbon, be also? So we find that the *chemical* value of the diamond is only equal to pure charcoal. But its intrinsic and commercial worth is much greater, as an ounce of the dust has brought two hundred and fifty dollars.

The diamond is the only gem that is infusible. It has been stated that after the great conflagration at Hamburg in 1842, many diamonds that had been defaced by exposure to the heat were sold for the merest trifle, under the supposition that they were permanently injured by the fire. Upon being repolished it was found that their former brilliance and lustre had returned, and they had only lost slightly in weight. The fact of the combustibility of the diamond was established by

experiments at Vienna in 1750, and others of more recent date. The old idea that the diamond could not be broken has been also exploded, and it is now known that the gem is very brittle. A fall on the floor has been known to seriously injure valuable specimens. Its formation is laminar, as it splits readily "with the grain," thus causing it to be easily divided into any desired size without the tedious process of cutting and grinding by friction.

There are three divisions of this gem into its different molecular states. First, the crystals, the most beautiful and perfect forms used in ornaments. Second, the imperfect crystals called bort, which is said to be excessively hard, far surpassing the perfect diamond in this respect. This kind is crushed into powder for polishing the more beautiful forms. Third, the uncrystallized or amorphous form. This is a steel-gray, opaque mass, called carbonado, which is also used in polishing. It is often porous, but possesses the hardness requisite for polishing.

Some gems have been known to split or burst from natural causes. This is more likely to happen with tinted specimens, especially those tinted with a faint brown. It is reported that specimens which were perfect upon being taken from the mines would, the next morning, be found lying in fragments from some cause which is still a matter of speculation.

While the diamond now stands undisputably first among gems, it has not always been so classed by all nations. The ancient Romans and Indians gave it first place, but the Persians only classed it as fifth in the scale, and other nations have given it the third place. Its possession was once claimed as a royal privilege, and none but the nobility presumed to appropriate it for ornament. It is supposed that the Phœni-

cians and Syrians were the first to use it in jewelry, but they did not long lack imitators, while to-day it has become a universal favorite, with its use limited only by the ability to purchase the gem. It was used very profusely in the earlier days by royalty. We are told that among the effects of Sultan Mahmoud at the beginning of the eleventh century were more than four hundred pounds avoirdupois of diamonds. The value of this gem to the ancient Romans and the early mediæval nations was not in the intrinsic beauty, for they had not yet learned to develop that beauty by polishing, but on account of its supposed supernatural powers. Being believed to promote harmony in the conjugal relations, it was at any early period chosen as the marriage ring.

The value of diamonds is dependent upon their size, color, and form of crystals. There are twin, triple, and even quadruple crystals that must have joined at the very instant of solidification. In the rough they are valued at half their weight. The Mohammedans say that the gems are the tears of Adam after his expulsion from Eden. In Europe large diamonds have been considered the badge of caste, but few were imported into the United States prior to 1848.

The first diamonds were found in India, and that country was long the only place known to have them. The mines of Golconda are often spoken of. This is an error, as Golconda has no mine; there is a fortress of that name where the gems are collected, cut, and polished in preparation for market. In 1727 it was discovered that diamonds could be found in Brazil, in the province of Minas Geraes. The first ones found were used as playthings by the children, and for counters at cards by the ignorant negroes. They were found in searching for gold. It was for the interest of the Indian

trade that these should be branded inferior to the Indian gems, and for some time they were so considered, but thorough investigation fully established their equality. The crops of all fowls killed in Brazil are examined for the diamonds they may possibly contain, and it is said that several quite valuable ones have been secured from this source. One man found a stone of five carats clinging to the roots of a cabbage he had pulled for his dinner.

In 1754 a slave, who had been transferred from the mines of the Minas Geraes region to the district of Bahia, noticed indications in the soil similar to that in which he had been working, and suspecting the presence of diamonds, he searched and found them to be abundant. This great find was the means of reducing the price about one-half. When a slave finds a diamond of seventeen or eighteen carats he is given his freedom.

The first authentic cutting and polishing of diamonds is credited to Louis van Berghem, of Bruges, in 1456, but the knowledge of the art must have long antedated this time, as it is known that there are very ancient church ornaments in existence which were cut as four-sided pyramids. Emperor Charles also had ornaments of polished diamonds. In the inventory of the effects of the Duke of Anjou, 1360–68, a diamond was mentioned, cut into the form of a shield. Van Berghem discovered that by continuously rubbing two diamonds together their surfaces were polished and facets formed. His experiments resulted in the adoption by him of diamond powder and the wheel for polishing purposes. It is, at least, considered that if not the original discoverer of this beautifying art, he certainly introduced many improvements by means of the wheel and by cutting the facets ac-

cording to mathematical principles. By so doing the art at once claimed its place among the sciences as well as the arts. Mr. H. D. Morse, of Boston, is the inventor of a machine for cutting and polishing gems to avoid the necessity for American jewelers having their gems cut abroad.

There are various forms in which precious stones are cut, the commonest of which are classed as table, brilliant, rose, and cabochon. The translucent and opaque varieties are usually cut *en cabochon*, the garnet being the only transparent stone which is advantageously cut *en cabochon;* that is, having no facets, or as convex, concave, double convex, or with one flattened and one convex surface. With the others there is a sacrifice of brilliancy if so cut. The old style of cutting diamonds several centuries ago was called the table or Indian cut. These were cut with a square or oblong plane on both sides, one much smaller than the other. Later the rose became the prevalent fashion. This consisted of a dome above a flat base, usually with a double row of facets. Smaller stones can be manipulated by using this form better than any other.

The one commonly in use is a later invention, and known as the brilliant, which is described as having the form of two cones joined at their bases, the upper one being truncated. The art of sawing diamonds when they were too thick in proportion to the required surface is said to have been invented by a Dutchman by the name of Dalbeck in the first part of this century. The flat, thin stones are cut in the table form.

The white varieties of other stones are often classed as diamonds by the uninitiated, but there are several tests to settle the question in doubt. One is that the diamond is the

only stone that will scratch the sapphire; another, diamond alone will cut glass. Other gems will scratch it, but the diamond will entirely separate its particles. Diamonds are sometimes ground steadily for a day without any perceptible effect upon their surface.

Among the curiosities belonging to Charles I, of England, there was an engraved diamond, the rarest ever known. It is supposed to have been sent by Henrietta Maria to that country to buy ammunition in time of war. Its vicissitudes were numerous, and it is now in Russia, the property of Prince Potemkni.

The measure of weight or carat, is equal to about four grains. Its name is supposed to be derived from the "kirat," the name of a bean, the fruit of a tree, known as the "kuara," which is a native of Africa. "Kuara" signifies "sun" in the language of that country, and the name was given to the tree because its flowers and fruit were flame colored. These seeds being always of nearly uniform weight, the natives have been in the habit, from time immemorial, of using them to weigh gold. These beans were transported into India at an ancient period, and have been there long used to weigh diamonds. The grains of the jewelers' carat are a little lighter than the Troy grains.

There are many exceedingly valuable specimens of this "king of gems," and there are also several magnificent claimants whose genuineness is doubted. Among the latter is the Braganza, owned by the government of Portugal. It has never been cut, and its weight has been variously estimated from one thousand six hundred and eighty to one thousand eight hundred and eighty carats. As the government seems to be jealous of any investigations, it is impossible to know

absolutely either its rank or its worth. It is thought by many that this stone is only a white specimen of some other gem, as the sapphire, topaz, etc.

A cablegram announces the finding on June 30th, 1893, of the "largest diamond in the world." It was found in the New Jagersfontein Company's mine in South Africa. It is said to be the most perfect stone found. Its weight is nine hundred and seventy-one carats, and its color is a blue-white. It was found by a Kaffir, who was working in the mine shortly after blasting. He handed it over to the manager and received seven hundred and fifty dollars, a horse, saddle, and bridle for it. The mine was worked under contract with some party to take all stones found, good, bad, or indifferent at so much a carat. This contract expired the day the large stone was found, and it was probably the last one found under it. The form of this magnificent gem is a sloping cone, flattened on two sides and standing on an oval base, so flush as almost to appear to have been cut. It is about three inches high, and its width about two, while the flat base measures nearly two inches by one and a quarter. It has been named the "Jagersfontein Excelsior," and is now in London.

It is thought that there are not many more than a hundred large diamonds in the world—those weighing over thirty carats. The oldest of these is the famous Koh-i-noor, or "Mountain of Light," as its name signifies. Its antiquity is traditional, as it is said to have been found in the Godavery River, Southern India, four or five thousand years ago, previous to the great Indian war of the Mahabharata. It was lost in this battle by the chief who wore it, and, coming into the possession of the family of the Rajah of Malwar, became the property of his successors for many generations, when

the Mohammedan conquerors of India appropriated it at the beginning of the fourteenth century. It was in the Imperial treasury at Delhi, until the Persian conqueror, Nadir Shah, carried it off in 1739. The wanderings of this gem from this time till it became an occupant of the royal treasury of Windsor Castle are many and various.

Previous to the "Excelsior," above described, the "Great Mogul" was the largest authentic diamond that had been found. It was discovered in 1650, and came into the possession of the vizier of the King of Golconda. On account of the king's jealousy, he was obliged to flee. Coming to Aurungzeeb, one of the most celebrated of the Mogul rulers, he purchased his favor by the magnificent presents he gave him. Among them was this gem, which thus received its name. Its weight when originally found is said to have been nine hundred carats, but it has been reduced by bungling artisans until it now only weighs two hundred and eighty carats. It was of the first water, or perfectly colorless stone, and valued at one million six hundred and eighty thousand dollars.

The next largest stone, the Pitt, or Regent, is now claimed to be the most conspicuous gem in the French crown. It was found in the mines at Puteal, India, in 1701, by a slave, who stole it and escaped with it to the coast, where he was decoyed on board an English ship by the captain, then robbed and cast overboard. This captain sold it for five thousand dollars, and, becoming dissipated, he eventually hung himself. Thomas Pitt, the grandfather of the celebrated William Pitt, bought the gem from a Parsee merchant. It was cut in London, as a brilliant, by hand, at a cost of twenty-five thousand dollars. The fragments have been estimated from seventeen

to forty thousand dollars. The work required two years. It was sold to the Regent of France, in 1727, from whence comes its name. It is estimated to be worth two million four hundred thousand dollars. It was exhibited at the Exposition of 1855. It is said there are no gems of more symmetrical form, transparency, purity, and beauty. Before cutting it weighed four hundred and ten carats, but was reduced to one hundred and thirty-six carats by that process.

Another gem, contesting for this second place, is the Orloff. It is absolutely impossible to accurately trace its history on account of the conflicting tales of romance, intrigue, and crime concerning it. It is frequently, in these records, confounded with both the Great Mogul and another gem, called the "Moon of the Mountains," which is a Persian stone. All agree that it is an Indian stone. It is said to have once formed the eye of a famous Indian idol, stolen by a French deserter and sold to an English sea captain, from whom it passed to a Jew, then to a Greek, and in 1772 was bought by Count Orloff for the Empress Catherine for four hundred and fifty thousand roubles and an annuity of four thousand roubles and a title of Russian nobility. The stone was set in the Russian sceptre and weighs about one hundred and ninety-five carats. It is the shape of half a pigeon's egg, and cut in the rose form.

Another famous gem is the Great Sancy. This has well been called "the sphinx among diamonds," on account of the conflicting, bewildering stories which claim to be its history. In this matter it holds first rank. A part of the trouble seems to arise from the fact that there are three gems called by that name. These are: the Great Sancy, the Demidoff Sancy, and the Little Sancy. Charles the Bold was supposed

to have been the first possessor of this gem of which any account can be found. He lost it on the day of his memorable defeat. The rest of its history is obscure till it is found in the hands of Nicholas de Harlay, Seigneur de Sancy, Ambassador of Henry IV of France to the court of Elizabeth. It is said that this is the first diamond ever polished.

It would be impossible within the space of this article to give an account of all the remarkable diamonds of the world. These "transparent images of eternal light" have many worthy representatives whose histories are wonderful and their beauties marvelous.

Red diamonds are very rare. There is one among the crown jewels of Russia which weighs but ten carats and cost seventy-five thousand dollars. A blue one, known as the "Hope Blue," was exhibited at London, in the Exposition of 1851, weighing forty-four and one-quarter carats, and estimated to be worth one hundred and twenty-five thousand dollars. Dresden has some fine yellow stones, the largest of which only weighs twenty-nine and one-half carats. There is also a green diamond at Dresden, which is exceedingly beautiful. It weighs forty and one-half carats, and is valued at one hundred and fifty thousand dollars. Messrs. Tiffany & Co., of New York, have a mixed diamond. Part of it is black and part white. They have also one which appears to be brown, but it gives out beautiful, dark rose-red reflections.

While the imitations of diamonds abound, it has thus far been proven a laborious and expensive task to manufacture genuine ones. Experiments conducted for this purpose have only resulted in the forming of such small crystals as not to threaten any competition to the natural market. Just at present the London chemists are greatly interested in the

attempts of one M. Moissan. He claims to have discovered a process by which he confidently expects to manufacture the gem in marketable quantities. He transforms graphite into diamond by the infusion of purified sugar. His experiments will be followed with great interest by the scientific world, and if he should succeed in his attempts, it will be unfortunate for the possessors of fortunes in these precious gems. It has long been believed that this great secret of Nature would be solved, and there have been many laborers in this department of science. Upon the eventual difficulty and expense of the manufacture of these gems will depend the degree to which the market will be affected.

## SAPPHIRES.

"The azure light of Sapphire's stone
Resembles that celestial throne."

The sapphire ranks next to the diamond in hardness, it being able to scratch every other stone. The Greeks considered it sacred to Jupiter. It is a blue, transparent variety of corundum, or native alumina. And every one knows that alumina is the principal ingredient in common clay. The ancients seem to have given the name of sapphire to all blue stones, or, rather, their term was hyacinthus. This primitive name, as well as our modern one, refers to its color—azure. It is supposed to have been of Syriac origin, and meant "to shine," as did also the Arabic "jacut," which is thought to have suggested the term "huakinthos" to the Greeks. According to the ancient Persians, the globe rests on a vast sapphire, the reflection of which colors the sky. In Exodus xxiv, 10, is written: "And they saw the God of Israel; and there was under his feet, as it were, a paved work of a sap-

phire stone, and, as it were, the body of heaven in his clearness." Epiphanes states that the vision which appeared to Moses on the mount was in sapphire, and that the first tables of the law given by God to Moses were made of sapphire. The blue sapphire is an emblem of heaven, virtue, truth, constancy, heavenly love, and contemplation. The clearness of the sapphire denotes hope. Sylvanus Morgan said, "The sapphire denotes prudence, distinguished by their sex, viz., male and female, whereof the bluest are thought to be the male." The wearing of it was supposed to quell the animal senses. It was also thought to be a great enemy to "black cholera," and that it would clear the mind and mend the manners of the wearer. It was powdered and mixed with milk, and taken as a remedy to cure boils.

The largest sapphire known is in the Mineralogical Museum, at Paris. It weighs a little more than one hundred and thirty-two carats, and was bought by a French jeweler for thirty-four thousand dollars. There is an account of another piece which was dug out of the alluvium at Ratnapoora, in 1853, weight not given, which was valued at more than twenty thousand dollars. The sapphire is a very cold gem, on account of its density, and this property gave rise to the belief that it would extinguish fires. The oldest ecclesiastical jewel extant is set with a sapphire, as, on account of its reputed ability to preserve the virtue of the wearer, it was considered the most appropriate gem for church uses. The sapphire has quite a range of color, being found in white, blue of all shades, red, and, more rarely, gray or green. It crystallizes in six-sided prisms, terminated in six-sided pyramids. Ceylon produces more of these gems than any other country, and they are noted for their great beauty and size. They are

also found in Arabia, and some other parts of Asia, Siberia, Bohemia, Greece, Saxony, France, Switzerland, Brazil, and the United States. The Ceylon mines have been worked for centuries. The blue diamond is distinguished from the sapphire by its superior brilliancy, and its ability to scratch the latter gem. There are several celebrated sapphires. One belonging to the Saxon crown, said to have been bought from an Afghan, and thought to be the finest one known. Baroness Burdett-Coutts Bartlett has two magnificent gems valued at nearly two hundred thousand dollars. There is one now owned by Queen Victoria, called the Lennox, or Darnley sapphire, which was set as a heart-shaped pendant for Margaret Douglass, in 1575. The ornament to which this is a pendant is a marvelous and complicated production of great beauty and value, and combines numerous mottoes and emblems.

The sapphire loses its color by the application of heat, but it thus acquires a great brilliancy, very nearly approaching the diamond, but not quite so iridescent. In the British Museum is to be seen a small statue of Buddha cut from a single sapphire. In the Hope collection are several specimens which exhibit varying colors under different kinds of light. The most celebrated of the antique sapphires is said to be the signet ring of the Emperor Constantinus II, which weighs fifty-three carats, and is in the Rinuccini collection.

A sapphire, once the property of Edward the Confessor, which was cut in the form of a rose, is now the centre of a cross in the crown of England. A remarkable specimen has been reported which is said to weigh nine hundred and fifty-one carats, of a beautiful blue tint, and without a flaw, belonging to the royal treasury of Ava, Burmah. As these State

jewels are jealously guarded, there is no vouching for this statement.

Sapphires were engraved as early as the fifth century.

Sapphires as beautiful and as genuine as those produced in the laboratory of Nature have been manufactured. Thomas J. Edison, the "Wizard of Menlo Park," makes those he uses in his inventions, and it is said that they are even superior in beauty to the natural gems.

### RUBIES.

"They brought me rubies from the mine,
And held them to the sun;
I said, 'They are drops of frozen wine
From Eden's vats that run.'"

Rubies are the red corundum. If they are perfect in color and of good size they are worth ten times as much as diamonds. The finest Oriental rubies come from Burmah, though they are found in many other parts of the world. Pliny, under the name of carbunculus, classed several stones; as the ruby, spinel, and garnet. The King of Burmah is called "Lord of the Rubies," on account of the extensive ruby mines about sixty or seventy miles from his capitol. Rubies are also found in Ceylon, Siam, Tartary, Bohemia, France, and America. To account for the abundance of rubies to be found in Ceylon, a Chinese work states that the origin of the trade in that island was coeval with the visit of the Hindoo god, Buddha, who sprinkled the land with sweet dew, which caused it to produce red gems. The belief was prevalent that impending evil was foretold by this gem by its turning darker or opaque in proportion to the intensity of the calamity. It was also supposed to give the power of seeing

in the dark, if hung around the neck, as well as to cure diseases of the eyes, if tied in a linen cloth over the forehead. The Arabs say: "Rubies purify the blood, quench thirst, dispel melancholy, avert danger, and insure honor, and that a true gem when put in the fire becomes invisible; in water, it glows with heat, and in the dark, shines like a hot coal." The Greeks called the ruby "anthrax," or "live coal." They believed it to give notice of poison, as do all the nobler gems, to grow dark on approach of evil, banish sadness, and many forms of vice and sin. Theoprastus said: "In the males, the stars appear burning within them, but the females throw out their brightness."

Pliny said: "The males are more acrid and vigorous, the females were languishing."

The finest rubies, those held in the highest estimation, are of a deep carmine hue, a red color known as "pigeon's blood." The rubies used in the ancient jewelry were polished, but seldom faceted, supposed to be on account of the native lapidaries disliking so strongly to waste any portion of the precious material. Antique engravings on this gem are very rare, and many of these supposed to be ruby are found to be some other form of crystals. There is one described by Chardin, the traveler and dealer in gems, which belonged to the Persian treasury. This was the size of half a hen's egg, and bore an inscription. It is also said that a Persian king owned a pink ruby which was engraved with the motto: "Riches are the source of prosperity." Rubies of undoubted genuineness have never been known to exceed twenty-four carats. Others much larger have been reported, but have generally been found to be something else. It is probable that the finest collection of rubies belongs to the

Russian treasury. Tavernier is authority for the statement that the throne of the Great Mogul was adorned with one hundred and eight rubies, weighing from one hundred to two hundred carats each.

The color of the ruby ranges from a deep cochineal to a deep rose red, being shaded with purple in some cases.

Another ancient belief concerning the ruby was that if it was bruised in water it would relieve infirmities of the eyes and help disordered livers. If the four corners of a house, garden, or vineyard were touched with it they would be preserved from lightning, tempest, and worms; it also dispersed infectious air. When worn it was impossible to conceal it, as its lustre would show beneath the thickest clothes.

### EMERALDS.

"The Emerald burns intensely bright,
With radiance of an olive light;
This is the faith that highest shines,
No need of charity declines."

Emeralds were supposed by the Orientals to have a miraculous origin. The story runs thus: "A person was watching a swarm of fire-flies in an Indian grove one moonlight night. After hovering for a time in the moonbeams, one particular fire-fly, more brilliant than the rest, alighted on the grass and there remained. The spectator, struck by its fixity, and approaching to ascertain the cause, found, not an insect, but an emerald, which he appropriated, and afterward wore in a ring." It was also believed that if a snake or serpent fixed his eyes on the lustre of an emerald he would become immediately blind. The Shah of Persia is said to have a little casket of gold blessed by Mahommed, which is capable of rendering him invisible as long as he remains unmarried.

Emeralds are supposed to have originally come from Peru, being brought to Europe through Asia. The finest ones are said to be obtained in Muzo, Colombia, but they are also found in Salzburg, Siberia, and India. They have been found in Norway, the Tyrol, France, Mexico, and North Carolina in the United States. It is said that Russia has the finest collection of emeralds in the world, one of them being as large as an egg. De la Vega said that the chief goddess of Peru was an emerald as large as an ostrich's egg, which was exhibited at great festivals. The people came from all parts of the country to behold their goddess and bring her gifts of emeralds. These gifts were called her daughters, and the priests gave the people to understand that she delighted in receiving them. When the Spaniards conquered Peru they captured these "daughters" without ceremony, but the "mother" had been so securely secreted that it is said that she has not since put in an appearance. Great quantities of very valuable emeralds were appropriated by Spanish brigands during their invasion of Mexico. Some finally found their way to the royal treasury of Spain. Cortez took five superb emeralds, of exquisite beauty and unique design, from a Peruvian temple and presented them to his wife.

The first of these gems was cut in the shape of a rose with its leaves, the second was a toy, the third was cut in the form of a bell with its clapper composed of one large pear-shaped pearl. It had engraved upon it in Spanish this inscription: "Blessed is he who created thee." The fifth of these wonderful gems was a cup, upon which was engraved in Latin: "Among those born of women, a greater has not risen." An offer of eighty thousand dollars was made for one of these

curiosities. These gems are now supposed to be lying buried deep in sand off the coast of the Barbadoes, as they were lost when Cortez was shipwrecked in 1529. Some authors claim that the second in this list was a horn. He still had other valuable emeralds left, among which were two vases, estimated at three hundred thousand ducats.

There is said to be a faultless gem weighing three hundred carats in the rich collection at Constantinople. It is set in the handle of a poniard. There was one found in the Temple of the Sun, in Peru, which was the size of a pigeon's egg. There is in the royal treasury of Persia an emerald the size of a walnut, upon which is engraved the names of the kingly owners, as it passed through their hands from time to time. The famous emerald mines of Mount Zebarah—"Mountain of Emeralds"—between the Nile and the Red Sea, Egypt, are supposed to have not been explored since the time of the Ptolemies until their rediscovery by a M. Caillaud. He found everything as it had been left by the miners centuries ago. Their appliances and tools were left carelessly about as though work would be resumed in the morning. There were some forty excavations carried to a depth of eight hundred feet below the surface of the ground, and four hundred men could work in them. The Arabs believed that these caves had been taken possession of by wild beasts and demons who would kill any intruder. The night before an entrance was effected they spent the entire night in firing guns to drive away these evil spirits.

Peru supplied the European markets till the discovery of the New Grenada mines. The gems found in these mines are considered the finest ever mined.

It is said that Ireland is called the "Emerald Isle" on

account of a ring set with an emerald, sent to Henry II of England, by Pope Adrian as the instrument of his investure with the dominion of that island. This ring, however, is not to be found.

The emerald is a gem of great antiquity. In a poem written by Orpheus, 400 B. C., the supernatural powers of this precious stone is alluded to. They abound in antique and Roman jewelry in the shape of slices of native prisms, in beads, and very rarely for intaglios. They were seldom engraved on account of their brittleness and objection to waste.

### THE TOPAZ.

From the Greek intagli which have come down to us, it is known that this gem was known to the ancients at a very early period. It is supposed that the name comes from an island in the Red Sea, known to the early nations as Topazos, where the gem was found. It is diffused over the world, being found in India, Siberia, Australia, Saxony, Austria, Brazil, Mexico, and several of the United States. It is found in a variety of colors, as saffron-yellow, wine-color, pale violet, sea-green, blue, gold, ruby, rose, sapphire-blue, and light blues. Its colors will fade in the light. It is seldom found in very large crystals without flaws. In Saxony, massive rocks are formed of it. The pure white topaz is often sold for diamond, which is easily done on account of its brilliancy. In the early times it was supposed that this gem had a gift of inner radiance that could dispel darkness, like the carbuncle. Set in gold and worn around the neck or left arm, it was a charm against all sorcery and magic, and it also could dispel nightmare, banish melancholy, cure cowardice, calm anger and madness, and brighten the wit.

## OPALS.

Pliny thus describes the opal: "Of all precious stones, it is opal that presents the greatest difficulty of description, it displaying at once the piercing fire of the carbunculus, the purple brilliancy of amethyst, and the sea-green of smaragdus (emerald)—the whole blended together and refulgent with a brightness that is quite incredible." The opal has well been said to hold within its magical influence all the gems it seems to embody, and is a natural prism. The name is derived from a Greek word meaning "eye," hence, it was believed to strengthen the sight. The Turks esteemed this gem as highly as the diamond. Large opals are exceedingly rare. The groundless stories founded on the legend of Robert the Devil have discouraged its use, as it is accused of bringing ill-luck to its wearer. The opal has thus far defied satisfactory imitation.

It is hydrated silica, and differs from quartz in containing from five to fifteen per cent. of water. The beautiful play of colors which it exhibits is owing to numerous fissures, which refract the light. It never crystallizes, and is always cut en cabochon, and not with facets. It has been known to split by holding a ring in which it was set too near the fire in frosty weather. There are several varieties—as the fire opal, jasper opal, wood opal, etc. The fire opal is found in Mexico, Hungary, and the Faroe Islands. It is remarkable for its flame-like reflections, of hyacinthine red, shading to honey yellow, and often showing prismatic colors. Vegetable products and trees are sometimes petrified into opal—hence, called wood opal. These do not display the prismatic hues of the true opal. The jasper opal retains the lustre of the

opal, but has the color of yellow jasper. The Romans secured their opals from the East, probably Ceylon, but the largest one known by them was not larger than the half of a hazel nut. There was one exception. Nonius, a Roman senator, was the possessor of one of the full size of a hazel nut, and because he would not surrender it to Marc Antony, on demand, for what that worthy considered an equivalent, he was exiled. It is said eight hundred and fifty thousand dollars was offered for it. The ancients are said to have understood how to successfully counterfeit the opal, but the art has died with them. The most celebrated modern mines are those of Hungary, Honduras, and Mexico. When first taken from the mine it is stated that the opal is transparent and colorless, but after being exposed to the light and heat it lessens in size and soon shows its natural iridescence, growing gradually more and more beautiful till the excess of moisture is driven off. The violet tint is first seen, then the others. The sunlight is the best colorer of the gem. The most notable opal of modern times was the one belonging to the Empress Josephine. It was called the "Burning of Troy," on account of the long flame-like emanations which shot forth from it.

The ancients believed it brought good-will to the wearer. Albertus Magnus said: "If you wish to become invisible, take an opal and wrap it in a bay leaf, and it is of such nature that it will make the by-standers blind—hence, it has been called "the patron of thieves."

### AMETHYSTS.

The origin of this precious stone is thus chronicled: "A beautiful nymph, beloved of Bacchus, was changed into the

amethyst, which represented the color of the god's favorite beverage. It is only a quartz, beautifully colored. Its name comes from a Greek word meaning "unintoxicated." It was in great demand by the Greek and Roman topers, on account of the belief that it had the power of preventing the evil consequences of their dissipation, made them vigilant and expert in business, expelled poison, gave victory to soldiers, and secured easy capture of wild beasts and birds. The Peruvians believed that if the names of the sun and moon were engraved upon it, and it was hung around the neck with the hair of a baboon, or the feather of a swallow, it was a charm against witchcraft. The best amethysts come from India, Persia, and Siberia, but they are found in Switzerland, Hungary, Brazil, and the United States. They are worth about five dollars a carat. They lose their color by the application of heat. It is most probably the easiest to imitate of any of the gems. It was thought that this gem was the best for ecclesiastical purposes.

### THE TURQUOISE.

The turquoise is a blue or bluish-green mineral. The first was found in Persia, and was brought to Western Europe by way of Turkey; hence, its name, turkis stone, or as the French have it, "turquoise." Large pieces are exceedingly rare. It is never crystallized, but is found as stalactitic masses, veins, nodules, and incrustations. Most specimens are liable to fade or turn green with age, though many of the oldest specimens known have still retained their beautiful blue tint which is so highly prized. It is the stone which was most commonly used for amulets, because of its mystical powers. The Syrian turquoise is found principally in low,

boggy earth. The ancients attribute to it the power to heal marital misunderstandings. It is also said to change in color and lustre according to the degree of health its wearer possesses, and thus to foretell coming sickness or death. Turquoise was first mentioned by an Arab in the twelfth century. It is the symbol of sincerity and fidelity. The best specimens are in the Persian and Russian crowns, and at Moscow there is a throne covered with more than two thousand of these gems. It is a mistake to suppose that they are to be found in Russia. This has arisen from the fact that they are polished and sold at Moscow by both Persian and Turkish merchants. The turquoise can be imitated.

## PEARLS.

"Its use and rate values the gem,
Pearls in their shells have no esteem."

Although, properly speaking, pearls cannot be called precious stones, as they have the same value and use, we cannot forbear speaking of them in this connection. The pearl has been considered, from time immemorial, as one of the loveliest gems that ever graced an ornament, and no labor or expense have been spared in the search for it. These gems are simply concretions of calcareous matter combined with the gelatinous substance secreted by the pearl oysters.

For centuries pearls formed an important item in the natural productions of Ceylon. The earliest native record of fishing for them is 306 B. C., and these oyster beds still continue to yield the gems. Suetonius says that twenty centuries ago the Romans procured pearls from Great Britain. The common Oriental belief concerning the origin of the

gems is that they are "rain from the sky, which turns into pearls as it falls into the sea." Pliny says the oysters produce them by feeding on heavenly dew. The oysters are dived for in from four to twelve fathoms of water. The present fishing ground of Ceylon is off the west coast of the island. The season begins in February of each year. Aripo is an old established fishing ground, having been used in the sixteenth century. Pearls are now found off Borneo, Australia, Central America, some of the Pacific Islands, and in the Gulf of California. The divers protect themselves from the sharks, those "tigers of the sea," by the use of charms. They will usually descend from forty to fifty times a day, bringing up from two thousand to three thousand oysters. The most favorable time for fishing is soon after sunrise. The diver generally claims one-fourth of the catch. The finest pearls are found in shells that are four or five years old. If young shells are brought to the surface they are returned to the water. The pearl oyster proper is twice as large as the Shrewsbury. Pearls are weighed by the grain instead of carat.

Pompey is said to have introduced the fashion for pearls into Europe. A cart was required to carry away the pearls which he took from Mithridates. Cæsar gave away a pearl worth a quarter of a million of dollars to Servilia, the mother of Brutus. Caligula had a pearl collar made for a favorite horse. The most famous pearl, the beautiful Peregrina, was found by a little negro boy in 1560. He obtained his liberty by opening the oyster. This bivalve was such a small one that he was about to throw it back into the sea in disgust, but on second thought he opened it and secured the magnificent gem. It is of the size of a pigeon's egg and pear-

shaped. It was presented by the little negro's master to Philip II, and is still in Spain. No sum has been set upon it, so it is virtually priceless. An offer of five hundred thousand dollars has been scouted. The single pearl which Cleopatra is supposed to have dissolved and swallowed had a value of four hundred and three thousand six hundred and forty-four dollars. This story is considered by many as apochryphal, because any acid which would quickly dissolve a pearl would do the same for the stomach of the drinker.

The largest pearl ever found in America is the Queen. It was discovered in the Notch Brook near Paterson, N. J. It was bought by Messrs. Tiffany & Co., of New York, who sold it to the Empress Eugenie for two thousand five hundred dollars. It was found in 1857. Pearls have also been found near Milford, Conn., and in the Little Miami River, Ohio.

Perfect pearls of the size of walnuts are called "paragons," when they are of the size of a small cherry they are known as "diadems." Pearls are also found in the rivers of Scotland, and a merchant of Edinburgh, Unger by name, has a necklace of these Scotch gems, valued at one thousand seven hundred and fifty dollars. They range from twenty-five to four hundred and fifty dollars each.

For a pearl to rank as "first quality" it must be iridescent, a pure white in color or of a delicate azure tint, and have a bright lustre. Those having a yellow tinge are considered as of inferior quality. When cut across pearls are found to be formed in concentric layers like an onion. The perfect sphere is the form which is held in the highest esteem, though misshapen pearls are often very valuable on account of their excellent quality or unique shapes. These freaks of

nature are called "baroques." The smallest sizes of pearls are called "seed pearls."

In former times powdered pearls were considered invaluable for stomach complaints. The pearl is the symbol of modesty.

## TUNNELS.

TUNNELS are mainly divided into two classes: natural and artificial. Of the first class there are many and varied examples, notably, Mammoth Cave, in Kentucky, U. S., and Fingal's Cave, off the southwest coast of Scotland.

### NATURAL TUNNELS.

Caves have been used from pre-historic times as places of abode, refuge, and sepulchre. Around them have also clustered many legends of myths and superstition. They were formerly considered the abodes of the gods, sibyls, and oracles. In the Roman mythology they were the homes of the nymphs; in the Grecian, they were used as the temples of their divinities, Pan, Bacchus, Pluto, etc., and from them were delivered the oracles at Delphi and other places. In Persia, they were used in the worship of their sun-god, Mithras. This god, by origin, was "the god of the bright heaven and day, closely related in conception to, and yet expressly distinguished from the sun." He was associated with the god, Varuna, and as a pair they denoted the heaven of day and the heaven of night. Their seventh month bore his name, and the sixteenth day of each month was sacred to his worship, when prayers were offered to him three times a day, morning, noon, and night. Upon the conquest of Assy-

ria and Babylonia, the Persian religion was greatly modified by these more cultured races. Mithras then became identified with the sun, and there was instituted for his worship an elaborate, mysterious ritual. The famous rest of the Seven Sleepers, of Ephesus, was taken in a cave. The Moorish children yet believe that the hills of Granada hold the great Boabdil and his sleeping hosts, who will be awakened to restore the Moorish magnificence of Spain, when some adventurous mortal shall invade their territory. Numerous instances are given in the Bible of the use of caves in the human economy, and need not be cited here.

The excavation of the natural tunnels of the earth, in a majority of cases, is obviously due to the erosive power of water, usually in the form of rivers, though the incessant swash of the sea breakers, with the steady grinding of the shingle, is also sure to find the weak spot or vein in the rock they so continuously bombard. The caves of volcanic regions are sometimes due to the expansion of the steam and gases incarcerated by the falling, flowing, molten mass of lava.

Caves are mostly found in the limestones of the Devonian, Carboniferous, and other ages. Their formation is due to the disintegrating influence of the carbonic acid contained in the water, together with the attrition of the detached *débris* carried onward by the force of the water. They are to be found principally in the limestone formations of the different ages and periods. They are found at various levels, and where the strata are compact enough to sustain a roof. They also occur in gypsum rocks.

Caves originating from the action of carbonic acid and water have their own peculiar characteristics. "They open on the abrupt sides of valleys and ravines at various levels,

and are arranged round the main axes of erosion, just as the branches are arranged round the trunk of a tree. In a great many cases the relation of the valley to the ravine, and of the ravine to the cave is so intimate that it is impossible to deny that all three have been produced by the same causes. The caves themselves ramify in the same irregular fashion as the valleys, and are to be viewed merely as the capillaries in the general valley system through which the rain passes to join the main channels." Instances are not uncommon where the streams are still flowing in their subterranean beds. Caves are still in all stages of production, from the simple funnel-shaped depression, called "pot-holes," to the stupendous cavern, whose area is still expanding by the agencies at work upon it. Many ravines were once caves, but have become unroofed through the degradation of the arching rock, which lies often throughout their entire length in masses of gigantic and varying proportions.

Stalactites and stalagmites usually abound in caves. These forms, as well as the more beautiful ones of efflorescence, are made by the deposition of the insoluble carbonate of lime left by the water which percolates through the rock and crystallizes in unique and often fantastic designs. Columns, another form of cave decorations, are formed by the junction of the stalactites with opposite stalagmites, where a continuous trickle of water acts for a long time. The beauty of the caves is greatly enhanced by the presence and number of these columns.

Caves which have been used as the residence of man and the lairs of wild beasts are classified according to the nature of the remains found in them. Those having the remains of animals now extinct, as the mammoth, woolly rhinoceros or

Paleolithic man, are known as Pleistocene caves. The ones which contain the remains of man in connection with those of the domestic animals, either in the Neolithic, Bronze, or Iron ages are called Pre-historic. There are still others of which we have the history, and they are, therefore, named Historic caves.

The quest for fossil bones, so highly esteemed for medicine in the sixteenth and seventeenth centuries, led to the discovery of the bone caves of the Hartz Mountain and other regions. These bones were those of the bear, hyena, lion, wolf, and fox, together with those of the reindeer, horse, and bison. Flint, stone, and bone implements are also found in the caves, giving clues as to the men who occupied them.

The pre-historic caves are distinguished from the others by their containing the bones of domestic animals, and the bones of wild animals found in them are those belonging to living species.

America has the honor of having the noblest specimen of caves in the world. It is located in Edmonson County, Ky., some eighty-five miles southwest of Louisville. Its discoverer was a hunter by the name of Hutchings in 1809, who was following the trail of a wounded bear. The mouth of this great cave is in a forest ravine, six hundred feet above sea level and one hundred and thirty-four feet above the Green River. The cavernous limestone in which it was found extends over an area of eight thousand square miles, and is of the Sub-carboniferous period. In this extent of surface there are numerous other caves vying with the Mammoth in beauty but not in size.

The temperature of this cave is uniformly fifty-four degrees Fahrenheit throughout the entire year. During summer

there is a strong wind issuing from the mouth of the cave, and in the opposite direction during the winter. The atmosphere is noted for its singular purity, and on account of its dryness has been considered beneficial for consumptives, but the experiments tried were not satisfactory on account of the absence of natural light. There are numerous ramifications to this cave which have been made the lines of various excursions. Of these there are two principal ones, called the long route and the short route. The former extends a distance of about eighteen miles, and the latter about half that length. This cave gives evidence of its pre-historic occupancy by the bits of half-burned cane torches and other signs. While the diameter of the entire cavern is less than ten miles, it is estimated that the aggregate of all accessible avenues equals about one hundred and fifty miles. Pits and domes abound, and the beauty of the gypsum crystal efflorescence is well known. This is not generally distributed throughout the entire cave, but confined to certain rooms. In the rainy season the vast volumes of water which enter through the numerous domes and pits collect in a room, known as River Hall. Here they form several large bodies of water, having connection by springs with Green River. In times of freshets in the Green River the streams of the cave have been known to rise sixty feet above the level of the low-water mark. These streams are only navigable from May to October of each year. They are severally called the "Dead Sea," "River Styx," "Lake Lethe," and "Echo River," which is the largest of all. There are fishes in these waters, but, of course, they are eyeless, for of what use could eyes be in perpetual darkness?

It would be an idle task to attempt a complete description

of the many and varied rooms and avenues of this monstrous tunnel. The literature of the cave is abundant and well repays the reading.

Fingal's Cave, on the island of Staffa, off the southwest coast of Scotland, is worthy of special mention, as it is a large excavation in columnar basalt; the same formation as the Giant's Causeway. This is the most remarkable cave in Europe.

### ARTIFICIAL TUNNELS.

The human animal is not content with the conquest of the surface of the earth for his benefit, but yearns for the control of the realms above and the dominion of the regions beneath. This is evidenced in the numerous attempts at aerial navigation, and the many uses to which tunnels have been put during the history of the world. Enterprise, science, ingenuity, and determination have broken down every barrier to human progress. Having subjugated the outside of the earth, man does not hesitate to make its interior tributary to his necessities and requirements. The tunnels of the world may well be classed among the "imperial works of man," even in these days which are so prolific in the achievements and triumphs of engineering skill. How true it is that this is a tunnelling age.

Tunnels are by no means a modern invention. Herodotus speaks of one, in the island of Samos, cut through a mountain nine hundred feet high. This tunnel was eight by fifteen feet, and measured four thousand three hundred and seventy-five feet in length. In Bœotia, Lake Copais was drained by a tunnel. Cæsar found that Alexandria was almost undermined by the numerous aqueducts through which water was carried from the Nile to the houses of that

city. The ancient Romans, Peruvians, and Mexicans had remarkable tunnelled aqueducts. According to Livy, a tunnel was begun in 398 B. C., at the instance of the Delphan oracle, to tap Lake Albanus. Fifty shafts were sunk, and it was completed within a year from the time of its commencement. It was six thousand feet long, with an orifice of six by three and a half feet. It was excavated through the hardest lava. The instruments used by the ancients were very crude, and the wonders they accomplished with them are truly marvelous. There was a tunnel under the Euphrates, at Babylon, in the time of Semiramis. This was constructed to connect the royal palace, which was on one side of the river with the temple of Jupiter Belos on the other side. There were two channels of communication between these two edifices, and both were stupendous works of art. One of them was a bridge supported by strong piers; the other, an arched tunnel, lined with brick, and it was twelve feet high by fifteen feet wide.

In the matter of tunnelling, Egypt led the world by many centuries. There were extensive tunnels opposite the Pyramids, which were used as quarries. Wherever the Romans conquered, there are found remains of tunnels for various purposes; as, drains, roads, water supply, etc. Passing notice must be taken of the famous excavation, the Cloaca Maxima, of ancient Rome, by which the sewage of that city was drained into the Tiber. The ground was so honeycombed by it and its tributaries that Pliny speaks of it as a city suspended in the air, rather than resting upon the earth. He says this stupendous drain was constructed by Tarquinius Superbus, though others from around the Forum and other valleys were commenced by Tarquinius Priscus. The an-

tiquity of the structure is evidenced by the stone of which it is built, as it is the same species that was used in the most ancient masonry. Its termination at the Tiber is still visible. There are three arches, one within the other, built of large blocks of stone. The innermost of these arches is more than thirteen feet in height. These large blocks of stone are joined together without cement. There are also similar drains in other Roman cities, but they do not approach the dimensions of this gigantic affair.

On the line of the Mersina Railway, in Asia Minor, there is a river which flows through a natural tunnel. At only a little distance from this point, there is another river flowing through an artificial tunnel, twenty feet wide by twenty-three feet high, which was cut upwards of sixteen hundred years ago, through rock of such density that the tool-marks are still visible, not being worn away by the action of the water during all these centuries.

It is thought that the Romans learned tunnelling from the Etruscans. It is certainly an index of civilization, as it has flourished and waned with the rise or decadence of nations.

Instances of modern tunnelling are so common that it would be impossible to give here a detailed account of them all, or even to mention them all. As adjuncts to railroading alone, there are several thousands of tunnels in service throughout the world.

The primitive method of tunnelling, before the invention of drilling machinery and other modern appliances, was by building fires against the rock to be excavated. When thoroughly heated, water was dashed against the hot surface, causing it to seam and crack, when it would be picked or

beaten off and removed from the cavity. The modern way of driving tunnels is to sink shafts and bore in opposite directions until the excavations from each end are joined. This plan is not always feasible, as in the case of what is known as the Mont Cenis Tunnel, through the Alps. Here, as well as in many other instances of mountain tunnelling, the great height of the mountain peaks precluded the use of shafts, so work had to be exclusively carried forward from each end, joining in the centre. The great problem in tunnelling is to run two, or more, lines of excavation so that they will meet and not miss each other. In the Mont Cenis tunnel, the lines of the opening varied about half a yard. The cutting of this tunnel and the accuracy of the junction is considered an unparalleled feat of engineering skill. It has an ascending grade from either end.

The first mention of the Mont Cenis Pass was about 755, when Pepin led his army across it to aid the Pope against the Lombard king. Fifty years after Charlemagne, his son, crossed with another army, having the same end in view. The name of Mont Cenis, however, for the tunnel, is a misnomer, as that mountain is from sixteen to twenty miles distant from either end. There are three peaks penetrated by the tunnel—Mount Tabor, Frejus, and Grand Vallon. When the tunnel was first proposed, it seemed but the idle dream of enthusiasts. The difficulties in the way might have well appalled the bravest and boldest of engineers. All possible objections were raised as to its practicability and worth by scientific men and others. There were all sorts of conjectures about it, and obstacles of all kinds thrown in the way. Fire, gas, water, or lakes, and even caverns, rock too hard to bore, and other terrible things might be encountered. One

great difficulty in boring tunnels was the excessive heat in them. This was greatly increased by the operations of blasting and driving the boring machines by steam. It was not till the combination of compressed air as a motor power with the borer that the work has been conducted with greater safety and expedition.

This stupendous piece of work was begun on August 31st, 1857. The object of the undertaking was to open up a shorter way of communication between the north of Europe and Italy, but it would never have been achieved, except for the marked improvements in engineering and mining appliances. The idea of a tunnel through the Alps is supposed to have been first advanced by M. Medail, a Piedmontese, about 1832, who showed where the range was the thinnest—between Piedmont and Savoy. Ten years later he gave the Italian government a plan for a tunnel through the ridge. Twenty-five years were spent in talk and investigations before the work was actually begun. The first part was hand work, but the drilling machine was introduced in 1861, which materially increased the rate of progress. The work upon this tunnel cost fifteen miliion dollars. It was completed in December, 1870, and in 1871 was opened for traffic. The method of perforating for blasting in this tunnel was in this wise: Holes at the centre, very near together, were first drilled. Then another row around these, at greater intervals, were drilled. The centre holes were first filled and blasted, which made a hole in the centre of the space, then another firing of the outer circle effected a complete breaking away of the rock. The drill perforator is described as a long carriage, all wheels and bars. It had from nine to twelve revolving chisels. There have been decided improvements in this

class of apparatus, which contrast strongly with the bulky engines first constructed. They can now make hundreds of strokes a minute, without cessation, and can be managed by one man. The drills, or perforators, are independent of each other, so if an accident befalls one, the work is not impeded. It can easily be withdrawn, at convenience, and readily replaced.

The Hoosac Tunnel, in Massachusetts, is another triumph in this line. At the time of its inception, it was thought such an impracticable project that the time of its completion was used as a synonym of eternity. The first idea was to perforate the mountain for a canal. The Hoosac Mountain stood in the way of the most natural low-grade route between Boston and the West. In 1848 the Massachusetts Legislature granted a charter to the Troy & Greenfield Railroad Co., for a road from Greenfield, Mass., to the State line of New York, which was to connect with a road to be built from Troy, N. Y. It was understood that this road was to pass through the Hoosac Mountain. Work was commenced on the west end of the road, in 1851, but the Legislature refusing its financial assistance, the work could not be continued until 1854, when the State loaned its credit to the amount of two million dollars, which was all that it was at first supposed the measure would require. State scrip was issued at various times. It was soon found that a much larger sum would be required, which was not forthcoming. Work was stopped July 12th, 1861, and the State foreclosed its mortgage, which it had taken upon the road and other property for security. After two or three years of investigation and figuring, the State resumed and managed the work till 1868, when a contract for its completion was made with the Messrs. Shanley,

of Canada, who finished the work as specified. It was thought that the work was built ahead of its time, as one terminus was only a country village and the other merely a State line. But to-day, wherever there are products to be moved in the United States, will be seen cars labelled, "Hoosac Tunnel Line." The first proposition for this tunnel was in 1820, before the days of railroading. The railroad proving, about this time, an assured success, it was decided to tunnel for a road-bed instead of a canal. Three routes were surveyed, but the original selection was confirmed and work commenced. Loammi Baldwin, the engineer, exclaimed, in reference to it: "It seems as if the finger of Providence had pointed out this route from the East to the West." A bystander is said to have retorted: "It is a great pity the same finger was not thrust through the mountain." The first machinery used in this tunnel weighed seventy-five tons. It was expected to cut a groove about a foot in width, conforming to the circumference of the tunnel. Then the core, thus formed in this centre, was to be blasted out or broken off with wedges. When it had entered the rock for ten feet, it broke down and proved its inadequacy for the work, and was eventually sold for old iron. Later, better machinery was substituted, and the work progressed to completion in November, 1873.

Another class of tunnels is known as the sub-aqueous, or those passing under rivers. One of the most noted of these is the Thames Tunnel. Sir Mark Isambard Brunel is the sharp-eyed, quick-witted, ingenious man who constructed this tunnel. The suggestion was given him by seeing a piece of ship timber perforated by that most destructive worm, the "teredo navalis." His study of the method of its working

brought out the idea of a "large cast-iron shield, which should bore like an auger, by means of strong screws, while as fast as the earth was cut away bricklayers should be at hand to replace it with an arch." His own description of this apparatus is: "An ambulating coffer dam, traveling horizontally." The previous attempts of Mr. Vasie, in 1805, and those of Mr. Trevethick, in 1807, were abortive, but the plans of Brunel were so acceptable to the Institute of Civil Engineers, as well as the public, that a company was formed, in February, 1824, and thirteen hundred and eighty shares of stock subscribed for. Work was commenced on March 2d, 1825.

It is said that if we will imagine an edifice of three rows each of twelve iron boxes, nine feet deep, six feet high, and three feet wide, each box faced with small movable boards, a good idea will be had of the Brunel shield for the workmen. It was placed in front of the completed brick arch, each man removing one or two boards and working out some clay. It would then be shoved forward into the excavation so made, that fresh surface might be presented to the operations of the workmen. During the construction of this tunnel, there were numerous accidents and incidents owing to the carelessness of the workmen and the breaking in of the river. The holes made by this latter catastrophe were filled by gravel and clay in bags which had witch hazel boughs thrust through them before sinking to place, so they would cling together. Rafts loaded with clay, and tarpaulins were also used. There were five irruptions of the Thames, at the second one of which there were six lives lost, but none in any of the other instances, except one man. The work was completed on August 1st, 1842, at a cost of two million three hundred and

forty thousand dollars. It was in 1818 that Brunel took out a patent for a new mode of making tunnels by means of an excavating machine, or shield. Some one has thus described it: "Beneath the great iron ribs of the shield, a kind of mechanical soul seems to have been created. It has its shoes and its legs, and uses them, too, with good effect. It raises and depresses its head at pleasure; it presents invincible buttresses in its front, to whatever danger might there threaten; and when the danger is passed, it again opens its breast for the further advances of the indefatigable host."

Of aqueduct tunnels, America has several fine specimens, of which perhaps the most notable is the new Croton aqueduct of New York city, which extends from the Croton dam to the reservoir in the city, a distance of thirty-three and a quarter miles. Practically the whole of this was tunnelled out of the rock. There were shafts sunk about one and a half miles apart and headings were driven each way.

Chicago has several aqueduct tunnels extending out into the lake to cribs for the intaking of the water supply of the city. On account of the contamination of the supply of drinking water, drawn from the lake, by the sewage which flowed into the Chicago river, the idea of securing a supply farther from shore, and at a distance where it was then thought this sewage could never affect, the idea of tunnelling to that distance was conceived. To Mr. E. S. Chesborough, an accomplished engineer, is due the credit of this idea. Upon investigation, his scheme was found to be perfectly feasible, and plans were prepared for its construction. This tunnel was pronounced, at that time, the greatest marvel the world ever saw, and the Thames Tunnel was considered but child's play beside it. The contract for the work was signed on the 28th

day of October, 1863, and specified that the work should be finished "on or before the 1st day of November, 1865."

This time had to be subsequently extended for years. Ground was not broken till March 17th, 1864, owing to delays in the casting of the immense cylinders for the shore shaft of the tunnel. The first attempts were unsuccessful on account of the quicksand encountered, and the contract had to be altered. The tunnel has a slope from the crib, or lake terminus to the shore of two feet in each mile, so that it might be emptied in the event of needed repairs. Two workmen could only work ahead of the masons, as the tunnel was so small, only five feet and two inches in height, and its width five feet. This made a very tedious operation, as it was damp and dark, and impure air abounded, making piping necessary for the transmission of fresh oxygen to the miners. The objective point of this tunnel was the crib in the lake. This was made on shore and built and launched like any other marine hulk. It was pentagonal in shape and made with three walls, one within the other, all firmly bolted together and thoroughly braced. Each wall was caulked and tarred to render it water-proof. This structure was launched on July 24th, 1865, and a gala day was made of the occasion. It was towed to its final resting spot by tugs, its flood gates were opened, and it sank beneath the water. When it had sunk to place it was filled with stone, excepting its centre compartment, which was reserved for the lake shaft. Cables were attached to its corners, and these were anchored to the bottom of the lake by marine mooring screws, which were already imbedded in the lake. A lighthouse was subsequently built over the centre. This was two miles from shore. After the shaft had been sunk in the crib to the re-

quired distance under the lake, a heading was started shoreward to meet the outcoming miners. During winter and the freezing over of the lake to this point, the corps of workmen at the lake end were cut entirely off from shore communication, except by means of signals. When the two lines finally joined, it was found that they did not vary as much as a whole inch. Well might it be said: "The work on the tunnel was comparatively nothing; it was the inception and the daring which determined to carry out the idea to a successful result that are among the wonderful. The confidence in the ability to burrow two miles out under the lake, and then come up to the surface in deep water, was of the sublime kind which assimilates to the faith that removes mountains." The two corps shook hands on November 24th, 1866. Since that date, the necessity has arisen, from the immense increase in the population of the Garden City, and the greatly increased contamination of the water, to add three other tunnels of various lengths, the last one being fully double the length of the first. So Chicago has several specimens of what the outside world denominated a "wild job," and declared could not be done. Beside these lake tunnels this city has two others under the Chicago river, for the use of the street cable railways, and one for foot passengers.

Tunnels have acquired such an assured place in civil engineering that there are scarcely any of the leading cities of the world which have not from one to many of them, used for various purposes.

Since the time, two thousand two hundred and eighty-eight years ago, when the miners of Furious Camillus drove the famous "Emissarium" through a part of Mont Alba and tapped the waters of a lake, to the present of engineering

perfection, the improvements in appliances have been almost incredible. Work which would then have taken years can now be accomplished in days, and in a much more finished manner.

As the adoption of tunnels has progressed, it is interesting to notice some of the objections urged against their construction. Perhaps one of the most senseless is the idea that by their use to connect foreign countries, the insular and peculiar characteristics of a people are destroyed.

Schemnitz, the principal mining city of Hungary, has a tunnel, the Joseph II Mining Adit, which has been claimed as the deepest gallery of efflux of that place, and the longest subterranean work of this kind in the world. It was commenced in 1782, during the reign of Joseph II, and completed September 5th, 1878. Its length is sixteen thousand five hundred and thirty-eight meters.

In 1871, Italy, Germany, and Switzerland voted large sums of money for building a road, to be begun immediately. It was to run from Lake Lucerne, Switzerland, to Lake Maggiore, Italy, one hundred and eight miles. Nearly a quarter of this distance was to be tunnelled through mountains of solid granite. The main tunnel entered the Alps at Groeschenen, Switzerland, and came out at Airolo, Italy. This section was forty-eight thousand nine hundred and thirty-six feet in length. There are also a number of smaller tunnels. The cost was greatly under-estimated, and when the mistake was discovered it threatened to kill the project completely, even though the work was fairly started. This blunder made a difference of one hundred and two million francs. The stock ran down, and many stockholders were nearly ruined by the collapse. It soon became apparent that if all was not lost, more must be added to the investments already made.

To add to the trouble, times were hard, crises were imminent, and war was on the continent. The required funds were finally raised, and the contract to complete the work was given to Louis Favre, of Geneva. Boring in this tunnel was done by compressed air-drills. There were fifty-five of these air-drills at work at each end of the excavation. These drills are thus described: "A large, long, iron framework some seven feet wide and six feet high and ten feet long, stands on a bit of railway built for the purpose close to the rock. To the sides of this iron frame are clamped little gun-metal cylinders, supplied with compressed air from the air-tubes running in from the compressors outside the tunnel. To the ends of the extending portions of these little cylinders are fastened the long iron drills, which are driven into the rock at the rate of one hundred and fifty strokes per minute. There is no boring in a proper sense, it is simply drilling. A simple contrivance causes it to turn over and over as the drill progresses. These machines punch holes into the rock about four feet deep, and are then moved back to a safe distance, while the holes so pierced are filled with long cartridges of dynamite, to be fired by fuses." These machines make a deafening noise while at work, and it is impossible to carry on a conversation, or even give orders, except by signals. In many of these tunnel excavations the darkness is so murky that signal lights are of no avail, and torpedoes, for warning to engineers, have to be resorted to. After a blast, the compressed air in the machine is allowed to escape, by which means the foul gases and smoke are gradually pushed to the rear and fresh air substituted for the workmen to breathe. These machines would progress sometimes eighteen or nineteen feet in a day, if the material to be excavated was not too

obdurate; again the rate of progress would only be ten and one-half feet for each machine.

Mr. Hellwag, the engineer-in-chief, invented the spiral tunnel, by which the line of travel was elevated, or raised in grade. There were three thousand five hundred persons employed in the construction of this tunnel. The perforators of a drilling machine are so adjusted that they attack the rock at different points and varying angles, upon a surface seven meters square. The average hole is from thirty to forty inches deep where the material will permit, but only about seven inches deep in the hardest quartz rock. The first rock-drill was patented by a man by name of Bartlett, in 1855, but these machines have since then been so modified, improved, and multiplied that there are now many different systems of these appliances.

The driving of the third of the Alpine tunnels, the Arlberg, was begun in 1880 and completed in a little more than three years, as by this time all mining apparatus had been so greatly improved that progress could be more speedy than formerly. Air-drills were used, and also a rotary hydraulic drill. After each explosion a fine spray of water was injected, which was of great benefit to the ventilation. Headings were made in each direction, right and left, from shafts which were opened up from twenty to seventy yards apart, so the work was expeditiously accomplished. This tunnel, when completed, measured six and one-half miles in length, while the St. Gothard was nine and one-half miles.

Many famous tunnels cannot be here described, and thousands of others cannot even be alluded to, but persons wishing to continue this subject will find an amount of literature upon the topic which merits perusal.

It is interesting to note the advance in the perfection of explosives, from the gunpowder of the first blast, to the finest tri-nitro-glycerine of the later work, manufactured, in the greatest purity, near the scene of action. Of this, more than half a million pounds were used in the excavation of one tunnel alone, the Hoosac. Nitro-glycerine was discovered by Sobrero in 1846, but we are indebted to Nobel for the key to its use in blasting. From his experiments with nitro-glycerine, Nobel invented dynamite, and, subsequently, the blasting gelatine.

Short cuts and expeditious transits are secured by the use of tunnels, and, from the evidences of the past, we are led to believe that there are no mechanical or natural difficulties which the persistence and ingenuity of man cannot surmount if necessity should require.

# LIGHT.

OF all the elements which play a high part in the material universe, the light which emanates from the sun is certainly the most remarkable, whether we view it in its sanatory, scientific, or æsthetical relations. It is, to speak metaphorically, the very life-blood of nature, without which everything material would fade and perish. It is the fountain of all our knowledge of the external universe, and it is now becoming the historiographer of the visible creation, recording and transmitting to future ages all that is beautiful and sublime in organic and inorganic nature, and stamping on perennial tablets the hallowed scenes of domestic life, the ever-varying phases of social intercourse, and the more exciting tracks of bloodshed and of war which Christians still struggle to reconcile with the principles of their faith.

The influence of light on physical life is a subject of which we, at present, know very little, and one, consequently, in which the public, in their still greater ignorance, will take little interest; but the scenes of light which, under the name of Optics, has been studied for nearly two hundred years by the brightest intellects of the Old and New World, consists of a body of facts and laws of the most extraordinary kind, rich in popular as well as profound knowledge, and affording

to educated students—male and female—simple and lucid explanations of that boundless and brilliant array of phenomena which light creates and manifests and develops. While it has given to astronomy and navigation their telescopes and instruments of discovery, and to the botanist, the naturalist, and the physiologist their microscopes—simple, compound, and polarizing—it has shown to the student of nature how the juices of plants and animals, and the integuments and films of organic bodies elicit from the pure sunbeam its prismatic elements, clothing fruit and flower with their gorgeous attire, bathing every aspect of nature in the rich and varied hues of spring and autumn, painting the sky with azure, and the clouds with gold.

Thus initiated into the mysteries of light, and armed with the secrets and powers which science has wrested from the God of Day, philosophers of our own age have discovered in certain dark rays of sunbeam a magic though visible pencil, which can delineate instantaneously every form of life and being, and fix in durable outline every expression, demoniacal or divine, which the passions and intellects of man can impress upon the living clay. They have imparted to the cultivators of art their mighty secret, and thousands of traveling artists are now in every quarter of the globe recording all that earth and ocean and air can display, all that man has perpetrated against the strongholds of his enemies, and all that he has more wisely done to improve and embellish the home which has been given him.

A branch of knowledge so intimately connected with our well-being, so pregnant with the displays of the divine wisdom and beneficence, and so closely allied in its æsthetical with every interest, social and domestic, might have been ex-

pected to form a part in our educational courses, or, through the agencies of cheap literature and popular exposition, to have commanded a place in the school and in the drawing-room, and to have gilded, if not to have replaced, the frivolities of fashionable life. Such expectations, however, have not been realized. Men of science, who are much in the society of the educated world, and especially of those favored classes who have the finest opportunities of acquiring knowledge, are struck with the depths of ignorance which they encounter, while they are surprised at the taste which so generally prevails for natural history pursuits, and at the passion which is universally exhibited even for higher scientific information which can be comprehended by the judgment and appropriated by the memory. The prevailing ignorance, therefore, of which we speak is the offspring of an imperfect system of education, which has already given birth to great social evils, to financial laws unjust to individuals and ruinous to the physical and moral health of the community. If the public be ignorant of science and its applications in their more fascinating and intelligible phases, if our clergy, in their weekly homilies, never throw a sunbeam of secular truth among their people, if legislators hardly surpass their constituents in these essential branches of knowledge, how can the great interests of civilization be maintained and advanced? how are scientific men to gain their place in the social scale? and how are the material interests of a great nation, depending so essentially on the encouragement of art and science, to be protected and extended? How are Europe and America to fare, if they will continue the only civilized nations which, amid the perpetual struggles of political factions, never devote an hour of their legislative life to the considera-

tion of educational establishments and the consolidation of scientific institutions?

Impressed with the importance of these facts, and in the hope that some remedy may be found for such a state of things, we have drawn up the following article in order to show how much useful and popular and pleasing information may be learned from a popular exposition of the nature and properties of the single element of light, in its sanatory, its scientific, and its artistic or æsthetical relations. Should our more intelligent readers arise from its perusal with information which they had not anticipated and which they had previously regarded as beyond their depth, our labor in preparing it will be amply rewarded, and we shall hope to meet them again in our surveys of the more popular branches of science.

In attempting to expound the *influence of light as a sanatory agent* we enter upon a subject which, in so far as we know, is entirely new, and upon which little information is to be obtained; but admitting the existence of the influence itself, as partly established by observation and analogy, and admitting, too, the vast importance of the subject in its personal and social aspects, we venture to say that science furnishes us with principles and methods by which the blessings of light may be diffused in localities where a cheering sunbeam has never reached, and where all the poisons and malaria of darkness have been undermining the soundest constitutions, and carrying thousands of our race prematurely to the grave.

The influence of light upon vegetable life has been long and successfully studied by the botanist and chemist. The researches of Priestley, Ingenhousz, Sennebier, and Decan-

dolle, and the more recent ones of Carradori, Payen, and Macaire have placed it beyond a doubt that the rays of the sun exert the most marked influence on the respiration, the absorption, and the exhalation of plants, and, consequently, on their general and local nutrition. Dr. Priestley tells us, "It is well known that *without light* no plant can thrive; and if it do grow at all in the dark, it is always *white*, and is in all other respects in a sick and weakly state." He is of opinion that healthy plants are in a state similar to sleep in the absence of light, and that they resume their proper functions when placed under the influence of light and the direct action of the solar rays.

The general result of experiments is thus given by their author: "Upon the whole, then, I am inclined to infer from the general tenor of the experiments I have hitherto made that both the exhalation and the absorption of moisture by plants, so far as they depend upon the influence of light, are affected in the greatest degree by the most luminous rays, and that all the functions of the vegetable economy which are owing to the presence of this agent, follow, in that respect, the same law." (*Phil. Trans.*, 1836, pp. 162–3.)

This curious subject has been recently studied in a more general aspect by Mr. Robert Hunt, who has published his results in the Reports of the British Association for 1847. Not content with ascertaining, as his predecessors had done, the action of the sun's white and undecomposed light upon the germination and growth of plants, he availed himself of the discovery of the chemical or invisible rays of light, and sought to determine the peculiar influence of these rays and of the various colors of solar light upon the germination of

seeds, the growth of the wood, and the other functions of plants.

In order to explain the results which he obtained we must initiate the reader into the constitution of the white light which issues from the sun. If we admit a cylindrical beam of the sun's light through a small circular aperture into a dark room, it will form a round white spot when received on paper. Now this white beam consists of *three visible* colored beams, which, when mixed or falling on the same spot, make white, and of *two invisible* beams, one of which produces heat and the other a chemical influence called actinism, which produces chemical changes, the most remarkable of which are embodied in photographic pictures. The whole sunbeam, therefore, contains *luminous* or colored-making rays, *heating* rays, and *chemical* rays.

When white light, therefore, acts upon plants, we require to know which of these rays produces any of the remarkable changes that take place; and as it is not easy to insulate the different rays and make them act separately, the inquiry is attended with considerable difficulty. By using colored glasses and colored fluids, which absorb certain rays of white light and allow others to pass, Mr. Hunt made arrangements by which he could submit plants to an excess of *red*, *yellow*, or *blue* rays, or to an excess of the heating rays, or of the chemical or actinic ones. In this way he was not able to study the pure influence of any of those rays in a state of perfect insulation, but merely the influence of a preponderance of one set of rays over others, which is sufficient to indicate to a certain extent their decided action. This will be better understood from a few results obtained with differently colored media.

| | Light. | Heat. | Chemical rays. |
|---|---|---|---|
| White light contains, . . . . . | 100 | 100 | 100 |
| Solution of bichromate of potash, . . . . | 87 | 92 | 27 |
| Solution of sulphate of chromium, . . . | 85 | 92 | 7 |
| Series of blue glasses, . . . . . | 40 | 72 | 90 |
| Solution of sulphate of copper, . . . . . | 60 | 54 | 93 |
| Solution of ammoniate of copper, . . . . | 25 | 48 | 94 |

It is very obvious that the action of the chemical rays will be obtained from the *three* last of these colored media, and the action of the luminous and heating rays from the two first, where the chemical rays are comparatively feeble. In this way Mr. Hunt obtained the following interesting results:

1. Light prevents the germination of seeds.

2. The germination of seeds is more rapid under the influence of the chemical rays, separated from the luminous ones than it is under the combined influence of all the rays, or in the dark.

3. Light acts in effecting the decomposition of carbonic acid by the growing plant.

4. The chemical rays and light (or all the rays of the spectrum visible to a perfect eye) are essential to the formation of the coloring matter of leaves.

5. Light and the chemical rays, independent of the rays of heat, prevent the development of the reproductive organs of plants.

6. The radiations of heat, corresponding with the *extreme red* rays of the spectrum, facilitate the flowering of plants, and the perfecting of their reproductive principles.

In *spring* Mr. Hunt found that the chemical rays were the most active, and in very considerable excess, as compared with those of light and heat. As the *summer* advanced, the

light and heat increased in a very great degree relatively to the chemical rays; and in *autumn* the light and the chemical rays both diminish relatively to the rays of heat, which are by far the most extensive.

"In the spring," says Mr. Hunt, "when seeds germinate and young vegetation awakes from the repose of winter, we find an excess of that principle which imparts the required stimulus; in the summer, this exciting agent is counterbalanced by another possessing different powers, upon the exercise of which the structural formation of the plant depends; and in the autumnal season these are checked by a mysterious agency which we can scarcely recognize as heat, although connected with calorific manifestations, upon which appears to depend the development of the flower and the perfection of the seed."

The very curious fact of plants *bending toward the light*, as if to catch its influence, must have been frequently observed. Mr. Hunt found that, "under all ordinary circumstances, plants, in a very decided manner, bent *toward* the light;" and, what is exceedingly interesting, when the light employed was *red*, from passing through red fluid media, *the plants as* decidedly bent *from* it. The property of bending toward the light is strikingly exhibited by the potato; and it has been found that the *yellow* or most luminous rays are most efficacious in producing this movement, while the *red* rays, as before, produce a repulsive effect.

If light, then, is so essential to the life of plants that they will even exert a limited power of locomotion in order to reach it, it is not unreasonable to suppose that it may be necessary, though to a less extent, for the development and growth of animals. When we look at the different classes

of inferior animals we hardly observe any relations with light excepting those of vision; but, under the conviction that light does influence animal life, various naturalists have devoted their attention to the subject. In his chapter "on the influence of light upon the development of the body," Dr. W. F. Edwards has given us some important information on the effect of light in the development of animals, or in those changes of form which they undergo in the interval between conception and fecundation and adult age—a process which, previously to birth, is generally carried on in the dark. "There are, however, animals," says Dr. Edwards, "whose impregnated eggs are hatched, notwithstanding their exposure to the rays of the sun. Of this number are the batrachians (frogs). I wished to determine what influence light, independently of heat, might exercise upon this kind of development." With this view, he placed some frog's spawn in water, in a vessel rendered impervious to light, and some in another vessel which was transparent. They were exposed to the same temperature, but the rays of the sun were admitted to the transparent vessel. All the eggs exposed to light were developed in succession, but none of those in the dark did well.

As almost all animals are more or less exposed to light after birth, Dr. Edwards thought it would be interesting to determine the peculiar effect of light upon the development of the body. As all animals, in growing, gradually change their form and proportions, and make it difficult to observe slight shades of modification, he chose for his experiments species among the vertebrata whose development presents precise and palpable differences. These conditions are combined in the highest degree in the frog. In its first period it

has the form and even the mode of life of a fish, with a tail and gills, and without limbs. In its second period it is completely metamorphosed into a reptile, having acquired four limbs, and lost its tail and gills and all resemblance to a fish. Dr. Edwards employed the tadpoles of the Rana obstetricians, and he found that all those which enjoyed the presence of the light underwent the change of form appertaining to the adult. "We see, then," says Dr. Edwards, "that the action of light tends to develop the different parts of the body in that just proportion which characterizes the type of the species. This type is well characterized only in the adult. The deviations from it are the more strongly marked the nearer the animal is to the period of its birth. If, therefore, there were any species existing in circumstances unfavorable to their further development, they might possibly long subsist under a type very different from that which nature had designed for them. The *Proteus Anguiformis* appears to be of this number. The facts above mentioned tend to confirm this opinion. The *Proteus Anguiformis* lives in the subterraneous waters of Carniola, where the absence of light unites with the low temperature of those lakes in preventing the development of the peculiar form of the adult."

The experiments of M. Morren on the animalcules generated in stagnant waters, and those of M. Moleschott on the respiration of frogs as measured by the quantity of carbonic acid gas which they exhale, confirm the general results obtained by Dr. Edwards; but the most important researches on the subject have just been published by M. Beclard, in the note which appears among the works at the head of this article. During the last four years he has been occupied with a series of experiments on the influence of the *white* and

*colored* light of the spectrum, on the principal functions of nutrition; and, in the note referred to he has presented to the Academy of Sciences, in a concise form, some of the more important results which he has obtained.

Having placed the eggs of the fly (*Musca carnaria*) in six bell glasses, *violet*, *blue*, *red*, *yellow*, *transparent*, and *green*, he found, at the end of four or five days, that the worms were most developed in the *violet* and *blue* glasses, and least in the *green*; the influence of the other colors diminishing in the order we have named them from violet to green. Between these extremes the worms developed were as three to one, both with respect to bulk and length.

In studying the influence of the differently colored rays upon frogs, which have an energetic cutaneous respiration, equal and often superior to their pulmonary respiration, M. Beclard found that the same weight of frogs produced more than twice the quantity of carbonic acid under the green than under the red glass. When the same frogs were skinned, the opposite result was obtained. The carbonic acid was then greater in the red than in the green rays.

In the number of experiments on the cutaneous exhalations of the vapor of water from frogs, the quantity was one-half less in darkness than in white or violet light, in which the exhalation was the same.

We come now to consider the influence of light upon the human frame, physical and mental, in health and disease, in developing the perfect form of the adult, and in preserving it from premature decay. We regret to find that our knowledge on these points is so extremely limited, and we are surprised that physicians and physiologists should not have availed themselves of their numerous opportunities in hospi-

tals, prisons, and mad-houses of studying so important a subject. We must grope our way, therefore, among general speculations and insulated facts in the hope of arriving at some positive results; and we have no doubt that the direct influence of light over the phenomena of life will not be found limited to the vegetable kingdom and the lower races of the animal world.

Man, in his most perfect type, is doubtless to be found in the temperate regions of the globe, where the solar influences of light, heat, and chemical rays are so nicely balanced. Under the scorching heat of the tropics, man cannot call into exercise his highest powers. The calorific rays are all powerful there, and lassitude of body and immaturity of mind are its necessary results; while in the darkness of the Polar regions the distinctive characters of our species almost disappear in the absence of those solar influences which are so powerful in the organic world.

It is well known to all who are obliged to seek for health in a Southern climate that an ample share of light is considered necessary for its recovery. In all the hotels and lodging-houses in France and Italy, the apartments with a south exposure are earnestly sought for, and the patient, under the advice of his physician, strives to fix himself in these genial localities. The salutary effect, however, thus ascribed to light might arise from the greater warmth which accompanies the solar rays; but this can hardly be the case in mild climates, or, indeed, in any climate where a fixed artificial temperature can be easily maintained. Something, too, is doubtless owing to the cheering effect of light upon an invalid, but this effect is not excluded from apartments so situated that out of a western or a northern window we may see the finest scenery illuminated by the full blaze of a meridian sun.

While the distinguished Sir James Wylie, late physician to the Emperor of Russia, resided in St. Petersburg, he studied the effect of light as a curative agent. In the hospitals of that city there were apartments entirely without light, and, upon comparing the number of patients who left these apartments cured, he found that they were only one-fourth the number of those who went out cured from properly lighted rooms. In this case, the curative agency could not reasonably be ascribed either to the superior warmth or ventilation of the well-lighted apartments, because in all such hospitals the introduction of fresh air is a special object of attention, and the heating of wards without windows is not difficult to accomplish.

But though the records of our great hospitals assist us in our present inquiry, yet facts sufficiently authentic and instructive may be gathered from various quarters. In the years of cholera, when this frightful disease nearly decimated the population of some of the principal cities in the world, it was invariably found that the deaths were more numerous in narrow streets and northern exposures, where the salutary beams of light and actinism had seldom shed their beneficial influences. The resistless epidemic found an easy prey among a people whose physical organization had not been matured under those benign influences of solar radiation which shed health and happiness over our fertile plains, our open valleys, and those mountain sides and elevated plateaus where man is permitted to breathe in the brighter regions of the atmosphere.

Had we the means of investigating the history of dungeon life—of those noble martyrs whom ecclesiastical and political tyranny have immured in darkness—or of those wicked men

whom law and justice have rendered it indispensable to separate from their species, we should find many examples of the terrible effects which have been engendered by the exclusion of all those influences which we have shown to be necessary for the nutrition and development, not only of plants, but of many of the lower animals.

Dr. Edwards, whose experiments on animals we have already referred to, applies to man the principles which he deduced from them; and he maintains even, that in "climates in which nudity is not incompatible with health, the exposure of the whole surface of the body to light will be very favorable to the regular conformation of the body." In support of this opinion, he quotes a remarkable passage from Baron Humboldt's *Voyage to the Equatorial Regions of the Globe*, in which he is speaking of the people called Chaymas: "Both men and women," he says, "are very muscular; their forms are fleshy and rounded. It is needless to add that I have not seen a single individual with a natural deformity. I can say the same of many thousands of Caribs, Muyscas, and Mexican and Peruvian Indians, whom we observed during five years. Deformities and deviations are exceedingly rare in certain races of men, especially those who have the skin strongly colored."

If light thus develops in certain races the perfect type of the adult who has grown under its influence, we can hardly avoid the conclusion drawn by Dr. Edwards "that the want of sufficient light must constitute one of the external causes which produce those deviations in form in children affected with scrofula; and the more so, as it has been generally observed that this disease is most prevalent in poor children living in confined and dark streets." Following out the same

principle, Dr. Edwards "infers that, in cases where these deformities do not appear incurable, exposure to the sun in the open air is one of the means tending to restore a good conformation. It is true," he adds, "that the light which falls upon our clothes acts only by the heat which it occasions, but the exposed parts receive the peculiar influence of the light. Among these parts we must certainly regard the eyes as not merely designed to enable us to perceive color, form, and size. Their exquisite sensibility to light must render them peculiarly adapted to transmit the influence of this agent throughout the system; and we know that the impression of even a moderate light upon these organs produces in several acute diseases a general exacerbation of symptoms."

The idea of light passing into the system through the eyes, and influencing the other functions of the body, though at first startling, merits, doubtless, the attention of physiologists. The light and heat and chemical rays of the sun, combined in every picture on the retina, necessarily pass to the brain through the visual nerves; and, as the luminous rays only are concerned in vision, we can hardly conceive that the chemical and heating rays have no function whatever to perform.

If the light of day, then, freely admitted into out apartments, is essential to the development of the human form, physical and mental, and if the same blessed element lends its aid to art and nature in the cure of disease, it becomes a personal and a national duty to construct our dwelling-houses, our schools, our work-shops, our churches, our villages, and our cities upon such principles and in such styles of architecture as will allow the life-giving element to have the fullest and the freest ingress, and to chase from every crypt and

cell and corner the elements of uncleanliness and corruption which have a vested interest in darkness.

Although we have not, like Howard, visited the prisons and lazarettos of our own and foreign countries in order to number and describe the dungeons and caverns in which the victims of political power are perishing without light and air, yet we have examined private houses and inns, and even palaces, in which there are many occupied apartments equally devoid of light and ventilation. In some of the principal cities of Europe, and in many of the finest towns of Italy, where external nature smiles in her brightest attire, there are streets and lanes in such close compression, the houses on one side almost touching those of the other, that hundreds of thousands of human beings are neither supplied with light nor with air, and are compelled to carry on their professions in what seems to a stranger almost total darkness. Providence, more beneficent than man, has provided a means of lighting up to a certain extent the workman's home by the expanding power of the pupil of his eye in order to admit a greater quantity of rays, and by an increased sensibility of his retina, which renders visible what is feebly illuminated; but the very exercise of such powers is painful and insalutary, and every attempt that is made to see when seeing is an effort, or to read and work with a straining eye and an erring hand, is injurious to the organ of vision, and must sooner or later impair its powers. Thus deprived of the light of day, thousands are obliged to carry on their trades principally by artificial light —by the consumption of tallow, oil, or carburetted hydrogen gas—thus inhaling from morning till midnight the offensive odors, and breathing the polluted effluvia which are more or less the products of artificial illumination.

It is in vain to expect that such evils, shortening and rendering miserable the life of man, can be removed by legislation or by arbitrary power. Attempts are gradually being made in various great cities to replace their densely congregated streets and dwellings by structures at once ornamental and salutary; and Europe is now admiring that great renovation in a neighboring capital, by which hundreds of streets and thousands of dwellings, once the seat of poverty and crime, are now replaced by architectural combinations the most beautiful, and by hotels and palaces which vie with the finest edifices of Greek or of Roman art.

These great improvements, however, are necessarily local and partial, and centuries must pass away before we can expect those revolutions in our domestic and city architecture under which the masses of the people will find a cheerful and well-lighted and well-ventilated home. We must, therefore, attack the evil as it exists, and call upon science to give us such a remedy as she can supply. Science does possess such a remedy, which, however, has its limits, but within those limits her principles and methods are unquestionable and efficacious.

Wherever there is a window there is light, which it is intended to admit. In narrow streets and lanes this portion of light comes from the sky, and its value as an illuminating agent depends on its magnitude or area, and on its varying distances from the sun in its daily path. But whether it be large or small, bright or obscure, it is the only source of light which any window can command; and the problem which science pretends to solve is to throw into the dark apartment as much light as possible—all the light, indeed, excepting that which is necessarily lost in the process employed. Let us

suppose that the street is a fathom wide or two yards, and that the two opposite faces of it are of such a nature that we can see out of a window a considerable portion of the sky two yards wide. Now, the lintel of the window generally projects six or eight inches beyond the outer surface of the panes of glass, so that if the window is at a considerable distance below the luminous portion of the sky, not a single ray from that portion can fall upon the panes of the glass. If we suppose the panes of glass to be made flush with the outer wall, rays from every part of the luminous space will fall upon the outer surface of the glass, but so obliquely that it will be nearly all reflected, and the small portion which does pass through the glass will have no illuminating power, as it must fall upon the surface of the stone lintel on which the window now rests. If we now remove our window and substitute another in which all the panes of glass are roughly ground on their outside, and flush with the outer wall, a mass of light will be introduced into the apartment, reflected from the innumerable faces or facets which the rough grinding of the glass has produced. The whole window will appear as if the sky were beyond it, and from every point of this luminous surface light will radiate into all parts of the room. The effect thus obtained might be greatly increased were we permitted to allow the lower part of the window to be placed beyond the face of the wall, and thus give the ground surface of the panes such an inclined position as to enable them to catch a larger portion of the sky. The plates or sheets of glass which should be employed in this process may be so corrugated on one side as even to throw in light that had suffered total reflection. In aid of this method of distributing light, it would be advisable to have the opposite faces of the

street, even to the chimney-tops, whitewashed and kept white with lime; and for the same reason, the ceiling and walls and flooring of the apartment should be as white as possible, and all the furniture of the lightest colors. Having seen such effects produced by imperfect means, we feel as if we had introduced our poor workman or needle-woman from a dungeon into a summer-house. By pushing out the windows, we have increased the quantity of air which they breathe, and we have enabled the housemaid to look into dark corners, where there had hitherto nestled all the elements of corruption. To these inmates the sun had risen sooner and set later, and the midnight lamp is no longer lighted when all Nature is smiling under the blessed influence of day.

But it is not merely to the poor man's home that these processes are applicable. In all great towns, where neither palaces nor houses can be insulated, there are, in almost every edifice, dark and gloomy crypts thirsting for light; and in the city of London there are warehouses and places of business where the light of day almost never enters. On visiting a friend, whose duty confined him to his desk during the official part of the day, we found him with bleared eyes, struggling against the feeble light which the opposite wall threw into his window. We counselled him to extend a blind of fine white muslin on the outside of his window and flush with the wall. The experiment was soon made. The light of the sky above was caught by the fibres of the linen and thrown straight upon his writing-table as if it had been reflected from an equal surface of ground glass. We recollect another case equally illustrative of our process. A party visiting the mausoleum of a Scottish nobleman wished to see the gilded receptacles of the dead which occupied its interior. There

was only one small window through which the light entered, but it did not fall upon the objects that were to be examined. Upon stretching a muslin handkerchief from its four corners, it threw such a quantity of light into the crypt as to display fully its contents.

But while our process of illuminating dark apartments is a great utilitarian agent, it is also an æsthetical power of some value, enabling the architect to give the full effect of his design to the external façade of his building without exhibiting to the public eye any of the vulgar arrangements which are required in its interior. The National Picture Gallery of Edinburgh, erected on the Mound, from the beautiful designs of the late W. H. Playfair, is lighted from above; but there are certain small apartments on the west side of the building which cannot be thus lighted, and these being very useful the architect was obliged to light them by little windows in the western façade. These windows are dark gashes in the wall, about two feet high and one foot broad, and being unfortunately placed near the Ionic portico, the principal feature of the building, they entirely destroy the symmetry and beauty of its western façade. Had there been no science in Edinburgh to give counsel on this occasion, the architect should have left his little apartments to the tender mercies of gas or oil; but science had a complete remedy for the evil, and in the hope that the two distinguished individuals who have the charge of the Gallery, Sir John Watson Gordon and Mr. D. O. Hill, will immediately apply it, we now offer to them the process without a fee.

Send a piece of the freestone to the Messrs. Chances, of the Smethwick Glass Works, near Birmingham, and order sheets of thick plate-glass the exact size of the present open-

ing, and of such a color that when one side of the glass is ground the ground side will have precisely the same color as the freestone. When the openings are filled with these plates, having the ground side outward, the black gashes will disappear, the apartment will be better lighted than before, and the building will assume its true architectural character. The plates of glass thus inserted among the stones may, when viewed at a short distance, show their true outline ; but this could not have happened if, during the building of the wall, one, two, or three of the stones had been left out and replaced by plates of glass of exactly the same size as the stones. This method of illumination will enable future architects to illuminate the interior of their buildings by invisible windows, and thus give to the exterior façade the full æsthetical effect of their design.

If it is important to obtain a proper illumination of our apartments when the sun is above the horizon, it is doubly important when he has left us altogether to a short-lived twilight, or consigned us to the tender mercies of the moon. In the one case it is chiefly in ill-constructed dwelling-houses and large towns and cities where a dense population, crowded into a limited area, occupy streets and lanes in almost absolute darkness, that science is called upon for her aid ; but in the other, we demand from her the best system of artificial illumination, under which we must spend nearly one-third of our lives, whether they are passed in the cottage or in the palace, in the open village or in the crowded city.

When we pass from the flickering flame of a wood fire to rods of pine-root charged with turpentine—from the cylinder of tallow to the vase filled with oil—from the wax lights to the flame of gas, and from the latter to the electric light—we

see the rapid stride which art and science have taken in the illumination of our houses and streets. We have obtained a sufficient source of light; we require only to use it safely, economically, and salubriously. The method which we mean not only to recommend, but to press upon the public attention, unites the three qualities which are essential in house illumination; but till our legislators and architects and the leaders of public opinion shall be more alive to the importance of scientific truths in their practical phase, we have no hope of being honored with their support. True knowledge, however, advances with time. Vulgar prejudices are gradually worn down; and in less than a century, whether we have the electric light or not, we shall have our artificial suns shedding their beneficent rays under the guidance of science.

The present method of lighting our houses, by burning the lights within its apartments, is attended with many evils. The intolerable increase of temperature in well-lighted rooms, whether they are occupied by small or large parties—the rapid consumption of the oxygen which our respiratory system requires to be undiminished—the offensive smell of unconsumed gas—the stench of the oleaginous products of combustion—the damage done to gilded furniture and picture frames—the positive injury inflicted on the eyes, by the action of a number of scattered lights upon the retina—and the risks of fire and explosion are strong objections to the system of internal illumination. About half a century ago, the writer of this article proposed to illuminate our houses by burning the gas externally, or placing it within the walls of the house, or in any other way by which the products of combustion should not vitiate the air of the apartment. The plan was received with a smile. It had not even the honor

of being ridiculed. It was too Quixotic to endanger existing interests or trench upon vested rights. Owing to the extended use of gas, however, its evils became more generally felt; but no attempt was made to alter the existing system till 1839, when a committee of the House of Commons was appointed to inquire into the best method of lighting the House. Many eminent individuals were examined; and in consequence of the report of the committee, the new system was adopted of lighting from without, or in which the air breathed by the members is entirely separated from the air which supplies the burners. A similar change has, we believe, been made in the mode of lighting the House of Lords, but the new system in its most general aspect has been admirably carried out in one or more apartments in Buckingham Palace, where the light is distributed from the roof, as if from the sky above, without any of the sources of light being visible. This method, of course, can be adopted only in halls or apartments with an external roof. In all other cases, considerable difficulties must be encountered in houses already built and occupied; but we have no doubt that the ingenuity of the engineer and the architect will overcome them, whether the system is to be accommodated to old buildings or applied in its most perfect state to houses erected on purpose to receive it. But, however great be these difficulties, it is fortunate that whether we are to have the advantage of the electric light or a purer form of carburetted hydrogen gas, the mode of distributing it will be, generally speaking, the same, and we therefore need not hesitate to introduce the new system on the ground that it may be superseded by another.

Having so recently escaped from the inhumanity of a tax which prohibited the light and air of heaven from entering

our dwellings, we trust that the governments of Europe will freely throw these precious influences into the dark abodes of their overcrowded cities, and that wealthy and philanthropic individuals will set the example of lighting, heating, and ventilating according to the principles of science. Dr. Arnott has already taught us how to heat our apartments with coal fires without breathing either the gases or the dust which they diffuse. Why should we delay to light them without breathing the noxious gas, and overlaying the organs of respiration with the nameless poisons which are generated in the combustion of the animal and vegetable substances employed in the furnishing of our apartments?

II. Having thus treated of the element of light in its sanatory relations, we shall now proceed to consider it in its scientific aspect. We do not propose to write an essay on optics; our sole object is to show to the unscientific reader how much interesting knowledge may be conveyed to him on subjects which he has hitherto shunned as beyond his depth. Though thirsting for scientific knowledge, he may have neither time nor taste for the perusal even of a popular treatise, and yet be delighted with instructive and memorable facts which can be interpreted by the eye, and with large views of the material world, which sometimes startle reason, and "make even the simple wise."

How few ever ask themselves the question, What is light? And how few could give a rational answer to it if put by their children! In a room absolutely dark there is obviously no light. The moment we light a gas-burner or a candle light streams from it in all directions as if it were something material, but diminishing in brightness more rapidly than the distance increases—that is, at twice the distance from the

burner it is four times weaker, at thrice the distance nine times weaker, and at four times the distance sixteen times weaker. Philosophers describe this property of light by saying that it varies as the square of the distance from the burner—four, nine, and sixteen, the degrees of brightness being the squares of the distances two, three, and four.

If light consists of material particles issuing from the sun or an artificial flame, we might expect to feel them impinging upon our tender skins, as we sometimes think we feel them on the retina when the eyes are extremely sensitive to the faintest light. If we open a bottle of musk in a very large apartment, the odoriferous particles immediately stream from it in all directions, but though they are really material, they neither affect the skin nor any other nerves but those of smell, and yet their size must be incomparably greater than those of light, which pass through glass and all transparent bodies whatever.

It was the earliest opinion of philosophers—that of Sir Isaac Newton, Laplace, and others—that light does consist of material particles, emitted from luminous bodies, thrown off from them by some force or power of which we know nothing, and reflected from the surfaces of all ordinary bodies, but a number of very remarkable experiments, made chiefly in our own day have led many philosophers to believe that light consists in the vibrations or undulations excited by luminous bodies in a medium called the luminiferous ether, which fills all transparent bodies, and extends to the remotest distances in space. It is supposed to be analogous to sound, which is propagated by vibrations or undulations in air, and the mode of its propagation may be illustrated by the beautiful circular rings or waves formed on the surface of stagnant water

round the spot where a stone has fallen upon it, or, what is more instructive, by the motion propagated along a field of growing corn. In the undulations on the surface of water the waves do not advance, as they appear to do, but merely rise and fall without carrying forward any light bodies that may be floating on their surface. In the field of corn the motion passes from each stalk to its neighbor, and consequently there is nothing moved from its place, a motion merely being propagated from stalk to stalk, as it may be from particle to particle of the luminiferous ether.

Whether we adopt the emission theory of Newton or the undulatory theory of Hooke and Huygens we must be startled with the fact, almost incredible, that in the one case the material particles are launched through space from all luminous bodies in all possible directions without their impinging on one another, and that in the other the waves or undulations of the elastic ether are circling in all directions from a thousand centres without being defaced or obliterated. If a number of intense odors were to be let loose from the same centre they would soon mutually interfere, and the fine waves on a peaceful lake if propagated from some adjacent centres would soon disturb each other and disappear. It is otherwise, however, with the radiant locomotives of light. Whether they be material particles or the vibrations of an elastic medium, they will ever carry, without the risk of collision, the great messages of the universe.

Now it is obvious that if any visible event were to happen on any of these planets or stars it could not be seen by us upon the earth till after the time mentioned in the table. If the nearest fixed star were to be destroyed it would continue to be seen by us for forty-five years after it had ceased to

exist, the last rays which issued from it requiring that time to reach the earth. In like manner, if our earth had been created six thousand years ago it would just now only have become visible at the most distant star, a point of space to which light takes six thousand years to travel.

These facts may be of some use to such of our readers as are familiar with certain recent speculations, which have as much science as to amuse us and as much fancy as to mislead us. The ingenious author of a little work, entitled, *The Stars and the Earth* asserts that "pictures of every occurrence propagate themselves into the distant ether upon the wings of the ray of light, and though they become weaker and smaller, yet at immeasurable distances they still have color and form, and as everything possessing color and form is visible, so must these pictures also be said to be visible, however impossible it may be for the human eye to perceive them with the hitherto discovered optical instruments." "The universe, therefore, incloses the picture of the past like an indestructible and incorruptible record, containing the purest and the clearest truth." The grave and pious Principal Hitchcock, taking up these views, has carried them far beyond the limits of science and common sense. The anonymous writer wants only new optical instruments, but the divine tells us "that there may be in the universe created beings with powers of vision acute enough to take in all these pictures of our world's history, as they make the circuit of the numberless suns and planets that lie enbosomed in boundless space. Suppose that such a being is at this moment upon a star of the twelfth magnitude with an eye turned toward the earth. He might see the deluge of Noah just sweeping over the surface. Advancing to a nearer star he would see the

Patriarch Abraham going out, not knowing whither he went. Coming still nearer, the vision of the crucified Redeemer would meet his gaze. Coming nearer still, he might alight upon worlds where all the revolutions and convulsions of modern times would fall upon his eye. Indeed, there are worlds enough, and at the right distances in the vast empyrean to show him every event in human history."

The anonymous speculator tells us that there are *pictures* of every occurrence inclosed by the universe on indestructible tablets, but he does not tell us what lens separates one picture from the infinite number of them which must exist, nor what is the tablet on which it is depicted, so that, granting him his instruments, he himself could not tell us when and how to apply them, or what they would exhibit. Let Dr. Hitchcock, too, have his "created beings" with the highest powers of vision, and place them on a star which the rays proceeding from Noah's deluge, sweeping over the earth, may just have reached. He forgets that the earth is revolving about its axis and moving round the sun—that clouds and darkness are periodically covering its visible hemisphere—that "every event in human history" does not occur in open day, and could not be seen by a contemporary observer placed anywhere above the earth's surface; and, therefore, that all his speculations have not only no foundation in science, but no meaning in sense.. The only truth which they so elaborately overlay is that there are stars in the universe so remote from the earth, or from each other, that the light of the one cannot reach the other till after the lapse of a great number of years—a simple corollary from the fact that light moves with the velocity of one hundred and ninety-two thousand five hundred miles in a second. Not content, how-

ever, with torturing this little truth, he calls in the aid of *electric reactions*, *odylic reaction*, *chemical reaction*, *organic reaction*, *mental reaction*, *geological reaction*, all words without meaning, in order to prove—first, that our minutest actions, and perhaps our thoughts, from day to day, are known throughout the universe! and, second, that in a future state, the power of reading the past history of the world, and of individuals, may be possessed by man!

Next in popular interest to the almost inconceivable velocity of light is the number of influences or elements of which a white beam of the sun's light is composed. It had always been supposed that the sun's light was perfectly white, heating as well as illuminating, every substance on which it fell; and that the colors of the rainbow, and of all natural bodies, were changes produced somehow or other upon white light, or were caused by the mixture of *white* light with different degrees or kinds of *blackness*. Sir Isaac Newton found, however, that *white* light consists of *red*, *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet* light in certain proportions, and that the *white* light which we see is a *mixture of all these seven colors*. If by any means we remove the *red* color, then the mixture of all the other colors will not be *white*, but have a blue tint; and if by any means we can take away the *blue* rays, the mixture of all the rest will be *reddish* or *yellow*. In like manner, if *we* remove or extinguish out of a beam of white light any one of the *seven* colors, or any part of one of the colors, the light will be no longer *white*, but *red* or *reddish*, *yellow* or *yellowish*, or *blue* or *bluish*, according to the color or the quantity of it that has been removed.

Now, all the leaves of plants and flowers, and all natural bodies whatever, have the power of absorbing every sort of

light which falls upon them, except light of their own color, which they reflect or radiate. When the sun's white falls upon the red petal of the *scarlet* geranium, the petal absorbs nearly all the other *six* colors which exist in the white light, and reflects only the *red*. In like manner, when the sun's light falls upon the *blue* petal of the *tradescantia virginica*, the petal absorbs nearly all the other rays, and reflects only the *blue*. That the *red* petal of the geranium, and the *blue* petal of the *tradescantia*, are not in themselves *red* and *blue* is evident from this, that if we throw upon them any other light, they will each appear *black*—that is, they derive their *red* and *blue* light solely from their reflecting the *red* and *blue* rays, which form part of the *white* light of the sun. Now these statements are perfectly true, if the *red* color of the petal in the one plant, and the *blue* color of the petal in the other, were the pure *red* and *blue* colors of the sun's light; but they never are so exactly, so that, when other colors than *red* fall upon the *red* petal, it is not black, but of a dark color; and when other colors than *blue* fall upon the *blue* petal, it is not *black*, but of a dark color—a result which Sir Isaac Newton thus expresses: "The colors of all neutral bodies have no other origin than this, that they are variously qualified to reflect one sort of light in greater plenty than another."

These observations of the origin of colors, and of the composition of white light, enable us to initiate the general reader into the subject of the *harmony of colors*, a species of knowledge easily acquired, and of essential importance in the art of painting, and in all the decorative arts. In studying the works of the ancient masters, it is obvious that they were not acquainted with the true principles of harmonious coloring; and, in modern times, we know of no artist but Mulready

who has evinced in his work anything like a thorough knowledge of the subject. Without descending into particulars, we state that *red* and *green* are harmonic colors, and *blue* and *yellow*. If the *red* verges upon the *orange*, the *green* must be *bluish-green*, and if the *blue* verges upon *green*, its harmonic *yellow* must verge upon *orange*. The reason why these colors harmonize with each other is that *red* and *green*, and *blue* and *yellow* make *white* light, for the same reason any number of colors in a painting would be harmonious, provided they are in such proportions as to make white light. This, of course, is true only as a general principle; for if the painting represented a brilliant sunset, there must be a predominance of red. In order to explain why harmonic colors should, when combined, make white light, we must refer to the curious physiological fact that when the eye is strongly impressed with any one color, it sees at the same time its harmonic color, or the color required to make white light. If you look steadily upon a red wafer upon a white ground for a few seconds, and turn the eye aside, you will see a green wafer. If you are in a room where the light of the sun passes through a bright red curtain, any hole or opening in the curtain will appear green. The reason of this is that the eye is rendered less sensible to red light by looking at the curtain, and, therefore, seeing less of red, which is in the white light of the hole or opening, the whole appears green. If a picture is painted with two leading colors which are not harmonic—suppose *bright red* and *bright blue*—then it is obvious that after the eye has been fixed on the *red* part, it will see *green*, and this green will appear as a spot on the blue part of the picture; whereas, if the two colors had been *red* and *green*, the green seen, after looking at the red, would not

appear as a spot on the real green of the picture. When two colors are harmonic, and placed in juxtaposition, they brighten one another, and the forms to which the colors are applied are more distinctly seen. If the hour and minute hands of a public clock, for example, are highly gilt, and the hours gilt on a *blue* ground, the time will be more distinctly seen than if any other colors had been employed.

Another department of optics which claims the notice of the general reader is that of vision—the way which we see and are seen. When we are told by some wise people that having two eyes we really see things double, though we have learned to consider them only single, and that we actually see objects upside down, though we have learned from experience that they stand upright, it is high time that we should know something on the subject. In the shutter of a dark room make a little hole, and place a small lens in it. Behind the lens hold a sheet of paper, and you will see the landscape inverted, and, if there are men in it, you will see on the paper their heads downward and their feet upward. This is the case in the human eye; every picture painted on the retina being inverted when we look at it behind, in an eye prepared for the purpose. But if, in the dark room, we place an eye behind the head of an inverted figure, and look through the hole or lens, we shall see the head uppermost, and if we place the eye behind the foot of the figure, and look through the hole or lens, we shall see the feet uppermost, and conclude that the figure is correct. Now, the eye is so constructed that every point of an image painted upon the retina is seen in a direction perpendicular to the point of the retina upon which it falls, and hence it is absolutely necessary to have an inverted picture of objects on the retina in

order to see them erect. With regard to double vision, it is quite true that when we see an object single, we see two pictures of the same object, one with each eye; but every one point of the one picture is seen in the same place and direction as every point of the other, and therefore the two pictures necessarily appear single throughout. If we had not the power, by the muscles of our eyes, to place the one image exactly upon the other, the two pictures would be visible. If we had an hundred eyes in place of two, and the power of directing their axes to one point, we should still see only one object.

Of all the triumphs which science has achieved in any of its departments, the most magical, and the one, too, least understood by unscientific persons, are the powers of the microscope and telescope. The power to enlarge a thousand times and render visible the minutest parts of objects whose very existence the eye cannot discover; and the power of magnifying to any extent, and bring within the scrutiny of the astronomer planets and stars and other celestial objects which the sharpest eye cannot descry in the heavens. It is not easy to explain the method of doing this without diagrams, but a sufficiently intelligible explanation may be obtained from well-known properties of lenses. If we place any object before a lens, an image of the object is formed behind it. If the object is near the lens, and small, the image will be distant and large, the sizes of each being proportional to their distance from the lens. If a small object, invisible to the eye, or imperfectly visible, is in front of a lens and placed near it, its image will be enlarged so as to make it visible; and by looking at this enlarged image with another lens we may magnify it much more, rendering what was invisible visible, and exhibiting structures unseen by the eye.

In the case of the heavenly bodies, or of distant objects on our own globe, we cannot bring them near a lens so as to produce an enlarged image of them to be afterward magnified. We use, however, lenses of a great focal length—that is, which form their image at a great distance behind them—and these images of distant objects are much larger than the small images of them formed by the eye. These enlarged images are again magnified by viewing them with a small lens. But as light is always lost in magnifying an object, it is necessary, as in the finest achromatic telescopes of glass, to have the lenses as large as they can be got, eighteen or twenty inches in diameter, to admit much light; and in the reflecting telescope, such as those of Lord Rosse, specula have been used three and six feet in diameter, to collect light enough to enable high magnifying powers to be applied to the images formed in the focus of the speculum.

There is one other property of light, discovered in our own day, of which it behooves every person to have some knowledge, however slight. It is the *polarization* of light, a remarkable property, which is often talked of by persons who do not know even the meaning of the name. If we reflect a ray of ordinary light, coming either from the sun or candle, from the surface of any transparent body, solid or fluid, at an angle between fifty-three and sixty-eight degrees—fifty-three degrees for *water*, fifty-six degrees for *glass*, and sixty-eight degrees for diamond—the ray of light so reflected is *polarized light.* Receive the polarized ray—the ray polarized by glass, for example—upon another plate of the same glass at an angle of fifty-six degrees, and turn the plate round to three hundred and sixty degrees, a complete circle, keeping the ray always incident at the same angle of fifty-six degrees; you

will observe four positions, distant ninety degrees, at which the light disappears, the glass being unable to reflect it, and other four positions, distant forty-five degrees from these, and ninety degrees from each other, where the light reflected is the brightest; the light reflected in all other positions increasing from the dark to the bright position. The *polarized light*, therefore, possessing these properties must have suffered some remarkable change by being reflected at an angle of fifty-eight degrees from the glass; and consequently it differs entirely from *ordinary light*, which is *equally* reflected from the glass during the rotation of the glass round the ray.

Let us now fix these two plates of glass so that ordinary light falling upon the first plate is polarized, and place the second plate in one of the four positions where the polarized ray will not be reflected, and the flame from which it proceeds appears as a black spot when we look into the second plate. In this simple little apparatus, which a child may make, we call the first plate of glass the *polarizer*, because it polarizes the ordinary light, and the second plate the *analyzer*, for reasons which we shall presently see. If we now take a thin slice of *gypsum* or sulphate of lime (which is as transparent as glass) about one-hundredth of an inch thick, and holding it between the polarizer and analyzer, we look into the analyzer so as to see the black spot through the slice of gypsum, we shall be surprised to find that, upon turning the slice around, there are four positions of it, distant ninety degrees, where the gypsum will have the most brilliant color—suppose red—restoring the light of the vanished flame, and that in other four positions, distant forty-five degrees from these, where all color disappears, and the black spot returns. If we now fix the film of gypsum in the position where it gives the

brightest *red*, and make the analyzer revolve round the polarized ray or black spot, we shall find two positions, one hundred and eighty degrees distant, where the red will be seen upon the black spot. At points forty-five degrees distant from these the red will disappear and the black spot return. At other four points, distant forty-five degrees from them, the gypsum will be of a bright green color, the colors getting paler and paler as the analyzer comes to the position which gives the black spot. Hence we see that when the slice of gypsum revolves, only one color, varying with the thickness of the slice, is seen, and when the analyzer alone revolves, *two* colors, *red* and *green*, or *blue* and *yellow*, are seen ; and these colors are always the *pure harmonic colors*. These two colors make pure white or colorless light, and they are analyzed by the analyzer, which, in one position, reflects to the eye one color, viz., the *red*, but is not able, in the same position, to reflect the other color, namely, the *green*. In another position, however, it reflects the *green* and not the *red*, so that it has analyzed, when mixed, the two colors, *red* and *green*, which compose the colorless light transmitted by the slice of gypsum.

If, instead of the slice of gypsum, we place in the apparatus plates of *Iceland spar*, *quartz* and *beryl*, etc., and make the light pass along the axis of the crystal, we shall observe the most beautiful phenomena of circular and highly-colored rings with a black cross ; and if we use biaxal crystals, such as *arragonite* or *nitre*, we shall see the most brilliantly-colored double system of rings along the principal axis of the crystal.

Our limited space will not permit us to give any further account of the wonderful properties of polarized light, and of the almost magical structures which it develops.

When we look with the most powerful microscopes at many transparent bodies, animal, vegetable, and mineral, we see no structure whatever; but when we make polarized light pass through them, it emerges with certain changes in its state, produced by the structure of the body, and these changes are rendered visible by the analyzer in a variety of tints, either faint or brilliant.

"The existence of solar rays accompanying light more refrangible than the violet rays, and cognizable by their chemical effect was first ascertained by Mr. Ritter; but Dr. Wollaston made the same experiment a very short time afterward, without having been informed of what had been done on the Continent. These rays appear to extend beyond the violet rays of the prismatic spectrum, through a space nearly equal to that which is occupied by the violet. In order to complete the comparison of their properties with those of visible light, I was desirous of examining the effect of their reflection from a thin plate of air, capable of producing the well-known rings of colors. For this purpose I formed an image of the rings, by means of the solar microscope, with the apparatus which I had described in the journals of the Royal Institution, and I threw this image on paper dipped in a solution of nitrate of silver placed at a distance of about nine inches from the microscope. In the course of an hour, portions of three dark rings were very distinctly visible, much smaller than the brightest rings of the colored image, and coinciding very nearly in their dimensions with the rings of violet light that appeared upon the interposition of violet glass. I thought the dark rings were a little smaller than the violet rings, but the distance was not sufficiently great to be accurately ascertained; it might be as much as one-thirtieth or one-fortieth

of the diameters, but not greater. It is the less surprising that the difference should be so small, as the dimensions of the colored rings do not by any means vary at the violet end of the spectrum so rapidly as at the red end. For performing this experiment with very great accuracy, a heliostat would be necessary, since the motion of the sun causes a slight change in the place of the image; and leather impregnated with muriate of silver would indicate the effect with greater delicacy. The experiment, however, in its present state, is sufficient to complete the analogy of the invisible with the visible rays, and to show that they are equally liable to the general law (of interference) which is the principal subject of this paper."

The beautiful process of the *Calotype* or *Talbotype*, viewed as a whole, was the undoubted invention of Mr. Henry Fox Talbot. As a new art which gave employment to thousands, he brought it to a high degree of perfection. He expended large sums of money in obtaining for the public the full benefit of his invention, and toward the termination of his patent, he liberally surrendered to photographic amateurs and others all the rights which he possessed, with the one exception of taking portraits for sale, which he conveyed to others, and which he was bound by law and in honor to secure to them. As Mr. Talbot had derived no pecuniary benefit from his patent, he had intended to apply for an extension of it to the Privy Council; but the art had been so universally practiced, that numerous parties were interested in opposing the application, and individuals were found who laid claim to the use of some of the chemical materials used in the calotype, and who combined with others to reduce the patent, and thus to prevent the possibility of its renewal. Although we are con-

fident that a jury of philosophers in any part of the world would have given a verdict in favor of Mr. Talbot's patent, taken as a whole, and so long unchallenged, yet we regret to say that an English judge and jury were found to deprive him of his right and transfer it to the public. The patrons of science and art stood aloof in the contest and none of our scientific institutions, and no intelligent members of the Government, came forward to claim from the State a national reward to Mr. Talbot. In France, the Government, by the advice of M. Arago, acted a very different part to Niepce and Daguerre, the inventors of the *Daguerreotype*. The invention was given as a present from the State to France, and even to Europe, and Niepce and Daguerre received between them an annual pension of six hundred and thirty-three pounds.

The great defect in Mr. Talbot's process, not in his patent, was, that *paper* was the substance upon which his calotype pictures were to be taken. He early saw the difficulty of obtaining this material of a suitable quality for photographic purposes, and he made many attempts to remedy the evil, but although several paper makers exerted themselves to the utmost, and succeeded, to a certain extent, in manufacturing a highly improved article, yet the size employed and various chemical substances used in the process, rendered it impossible to procure paper of that fineness and uniformity of texture which the advanced state of the art required. When the artist had bestowed the greatest pains in taking a negative picture, and had taken it sometimes two or three times, he often found his own labor lost, and the expectations of his sitters disappointed.

Under these circumstances the idea occurred to M. Niepce

St. Victor, Commandant of the Louvre, to whom photography owes so many obligations, to reject paper altogether for negatives, and to use a film of albumen spread upon glass. To do this he takes five ounces of the whites of fresh eggs, mixed with one hundred grains of iodide of potassium, twenty grains bromide of potassium, and ten grains of common salt. This mixture is beaten up with a fork, and after resting all night it is ready in the morning for use—that is, it is ready to spread into a uniform film upon glass, and employed instead of paper for taking negative photographs.

The great advantage of the albumen process is that the film is perfectly smooth and homogeneous, and may be obtained of a very large size. Its defect, however, is its want of sensibility, so that it can be employed only for statues and landscapes. It seems to have been very little used in England, but has been brought to perfection by Messrs. Ross & Thomson, of Edinburgh, who, to use the words of Mr. Hunt, "have been eminently successful operators with it, many of their pictures, which are of a large size, exhibited more artistic effect than is obtained by any other photographers. Some of the positives produced are very fine. At the last meeting of the British Association in Edinburgh, these gentlemen exhibited some positive images on glass plate. These were backed up with plaster of Paris for the purpose of exalting the effects, which were exceedingly delicate and beautiful. We have now before us six of these magnificent photographs, fifteen and a half inches by fifteen and a half inches, representing Edinburgh from the Calton Hill, interior of Holyrood Chapel, Melrose Abbey in two aspects, the Golden Gate of St. Andrew's Cathedral, and the north doorway of Dunfermline Cathedral, Benan, and Benvenu, and we have

no hesitation in saying that they surpass everything that has been done in this process.

Owing to the great length of time required to take a photograph in albumen, various attempts have been made to render it more sensitive or to obtain a more sensitive material equally uniform and manageable. Mr. Hunt had, in 1884, recommended the use of the fluorides, and M. B. Everard has lately employed the fluoride of potassium along with the iodide of potassium as a means of obtaining instantaneous images on albumen. Mr. Hunt has found that the image appears immediately on exposure in the camera, and anticipates great advantages from the use of the fluorides.

For the same reason M. Niepce St. Victor has recently published a process, in which, in place of albumen, he employs seventy grains of starch rubbed down in seventy grains of water, and then mixed with three or four ounces more of water. After five and a half grains of iodide of potassium are added the whole is boiled till the starch is properly dissolved. It is then laid upon a plate of glass and is said to give tablets of great sensibility. The serum of milk and gelatine and other substances have also been proposed and used to obtain a surface more transparent than paper and more sensitive than albumen, but most of them have been abandoned, at least for portraits, since the introduction of *collodion* by Archer in 1850.

The discovery and use of collodion is doubtless the greatest improvement that has been made in photography. Collodion is a limpid fluid of the color of sherry, and is made by dissolving gun-cotton in ether containing a little alcohol. Gun-cotton is made by mixing seventy grains of fine selected cotton with water, nitre, and sulphuric acid in the proportions

of three, four, and five ounces. After the cotton has been washed in this bath by stirring it with two glass rods, it is taken out, well washed with water to remove every trace of acid and hung up to dry. Fifteen grains of gun-cotton, thus prepared, is placed in a mixture of nine fluid ounces of rectified sulphuric ether with one ounce of alcohol sixty degrees over-proof. The cotton will be almost wholly dissolved with the exception of some fibres, which will fall to the bottom. The clear solution or collodion when poured off is ready to be iodized by adding to it a certain quantity, to be determined by experiment, of an alcoholic solution of the iodide of silver and the iodide of potassium. A glass plate, well cleansed from grease, is coated with a thin film of collodion, obtained by pouring a small quantity on the plate, and running it off by one corner into a bottle. This film, solidified by the evaporation of the ether, is now excited by a solution of thirty grains of nitrate of silver in one ounce of water. It is placed in the camera, and the image developed and fixed by processes, which we cannot, of course, here find room to detail.

Collodion may be prepared from paper, flax, the pith of the elder, and many other vegetable substances. In whatever way it is made, the name of *pyroxylin* is given to it. *Lignine*, or the true substance of wood, is convertible into a substance analogous to true gun-cotton. *Lignine*, combined with strong nitric acid, forms a substance called *xyloidide*. The preparations of collodion by R. W. Thomas are in much esteem, and are sold under the name of *Xylo-iodide of Silver*.

Although M. Biot, in 1840, considered it as an illusion to expect photographs having the color of the objects which they represent, yet a certain advance, and one of some importance,

has been made to this result. In a former article we referred to the attempts of M. Claudet and Sir John Herschel to copy the colors of nature. Mr. Hunt "procured colored images, not merely impressions of the rays of the spectrum, but copies in the camera of colored objects." But the most important results have been obtained by M. Edmund Becquerel, and M. Niepce St. Victor of Paris.

In November, 1884, M. Edmund Becquerel exhibited to the Academy of Sciences "a photochromatic image of the solar spectrum, and colored photographs obtained in the camera obscura." These photographs were on daguerreotype plates; and there can be no doubt that all the colors of the spectrum, and those of natural objects were obtained by his process. Unfortunately, however, no method of fixing them could be found, and the colors disappeared very quickly when exposed to light, though they could be preserved for a long time in the dark.

M. Niepce St. Victor has pursued this subject with more success than his predecessors. Mr. Hunt has examined pictures of his on metallic plates "in which every color of the original was most faithfully represented," but they eventually faded into one uniform reddish tint; and M. Niepce St. Victor tells us that he has made a hundred attempts to fix these *helio-chromes*, as he calls them, without the slightest success.

Important as these researches are, M. Niepce St. Victor has published two "Memoirs" on a new action of light, which has excited much interest in the scientific world. Having exposed for a quarter of an hour to the sun's direct rays an engraving which had been kept several days in the dark, he applied the engraving to a sheet of sensitive paper, and after twenty-four hours' contact, he obtained a negative picture of

the engraving. If the negative, taken from a dark place, where it has been for several days, be applied to a sheet of the sensitive paper, without exposure to the direct rays of the sun, no negative picture is produced. Wood, ivory, gold-beater's skin, parchment, and even the living skin, struck by light, will give a negative picture; but metals and enamels will not. If a film of mica, glass, or rock crystal is placed between the engraving and the sensitive paper no negative picture will be got; but if the engraving is covered with a stratum of collodion or gelatine, the picture will be obtained. If the distance between the engraving and the sensitive paper is only three millimetres, or one-eighth of an inch, a picture will be produced; and if the lines of the engraving are strong, a distance of a centimetre will not prevent it. If we take an opaque tube, shut up at one end and lined with paper, and expose the open end for an hour to the direct rays of the sun and if at the end of twenty-four hours we apply the open end of the tube to a piece of sensitive paper, we shall obtain a negative image of the opening. If the tube be hermetically sealed after exposure to the sun's rays, it will preserve for a long time the power of acting upon sensitive paper. M. Niepce St. Victor placed a sheet of white paper that had been in the dark in the camera, where it continued to receive for three hours an image brilliantly illuminated by the sun. When taken out and applied to a sheet of sensitive paper, it reproduced very visibly, in twenty-four hours, the original image in the camera obscura.

In his second Memoir our author exhibits this "persistent activity" or "storing up" of light, as he calls it, in another interesting experiment. He places a glass or paper negative upon a sheet of paper that has been several days in the dark,

and after a sufficient exposure to the sun's rays, he takes out the paper in the dark, and develops the picture by a solution of nitrate of silver, and fixes it by merely washing it in pure water. In order to obtain a picture more quickly and more vigorously developed, he impregnates the sheet of paper, till it becomes of a pale, straw yellow color, with an aqueous solution of *nitrate* of *uranium*, "which admits in a higher degree than the paper the luminous action of storing up with the persistent luminous activity." The picture, when taken, as before, is fixed by simple immersion in pure water till the salt of uranium is completely removed. Thus fixed the pictures resist the energetic action of a boiling solution of cyanuret of potash; and we may, therefore, hope that they will be indestructible by time. This great discovery of M. Niepce St. Victor will be received with surprise by the scientific world, who regard light and all its chemical influences as the effect of simple motion. When light has been stored for days, it is difficult to understand how it can afterward begin to vibrate and perform all its former functions.

Although M. Niepce St. Victor's experiment on the permanence of the nitrate of uranium photographs is very interesting, yet time only can solve the problem of their absolute indestructibility; and we must continue to practice the art with all the fears and misgivings of the past. It is fortunate, however, that several processes have been invented by which photographs can be rendered as permanent as engravings and multiplied to any extent. The best of these processes is the photo-galvanographic one of Mr. Paul Pretsch, who, after his right by patent, established a company at Islington, and has published, in a series of numbers, magnificent specimens of the art. Solutions of glue in solutions of nitrate of

silver, iodide of potassium, and bichromate of potash are mixed according to a rule and spread like albumen over the glass plate. A photograph or engraving is placed on the prepared plate and a negative taken in sunlight. The glass is then placed in water, with a little alcohol and the darkened spots are rendered soluble, while the other parts are insoluble, so that in a few minutes we have a picture represented not only by light and shadow, but by the unequal thickness of the gelatine on the glass. When the plate is dry, soft gutta-percha is pressed upon the picture until it hardens. The gutta-percha has consequently an image the reverse of the first. After rubbing it over with bronze powder or black lead, it is placed in a solution of sulphate of copper, and an electrotype plate taken from it, in the usual way, with a voltaic battery. From this plate others can be readily taken, and, as in ordinary copper-plate printing, thousands of copies can be thrown off. "By this process," says Mr. Hunt, "pictures, in which the most delicate details are very faithfully preserved, and the nice graduations in light and shadow maintained in all their beauty, are now printed from the electrotype plate obtained from the photograph. The process of photo-galvanography is evidently destined to take a very high position as a means of preserving the beauties of nature and art.

In miniature painting it has taken a new profession. Mr. Duppa, distinguished artist, after making his photograph transparent, paints with oil colors on the back of the photograph, so that he never can take away the original likeness. Mr. Dickinson, on the contrary, and others, paint upon the photograph itself; and, at a trifling risk of affecting the likeness, they have the power of correcting defects, both in form and expression, which exist in almost every sun-picture.

To the landscape and historical painter photography has proved an invaluable assistant. Messrs. Ross & Thomson published, some time ago, the most beautiful photographs for foregrounds, taken while growing at the foot of rocks and trees. Of these, the ferns, the dock leaves, the fox-glove, and the nettle are beyond all praise; but, charming as these are, they are surpassed by two on a larger scale, which have recently appeared under names of "The Quiet Corner" and "The Dykeside." These photographs, fifteen and one-half by fifteen and one-half inches, full of the poetry of vegetable life, teem with wild plants of the most picturesque and lovely forms, and rich in the variety and luxuriance of leaf and stem. Though devoid of fragrance and of color, they allure us to the cooling fountain which waters them. They tempt us to nestle in the little rocky hollow which they adorn, and to weep with human sympathies amid creations that are fated but to bloom and die.

The most important application of photography has certainly been to the stereoscope, not only in reference to art, but to the great purposes of education and to the illustration of works on every branch of knowledge. The surface of the moon has been drawn with singular beauty. The eclipses of the sun and moon have been delineated, and various other astronomical phenomena which the observer could not otherwise have recorded. But, perhaps, one of the most curious applications of the art has been the microscopic portraits, as executed with such skill by Mr. Dancer, of Manchester. Some of these are so small that ten thousand could be included in a square inch, and yet, when magnified, the pictures have all the smoothness and vigor of ordinary photographs.

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